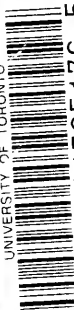


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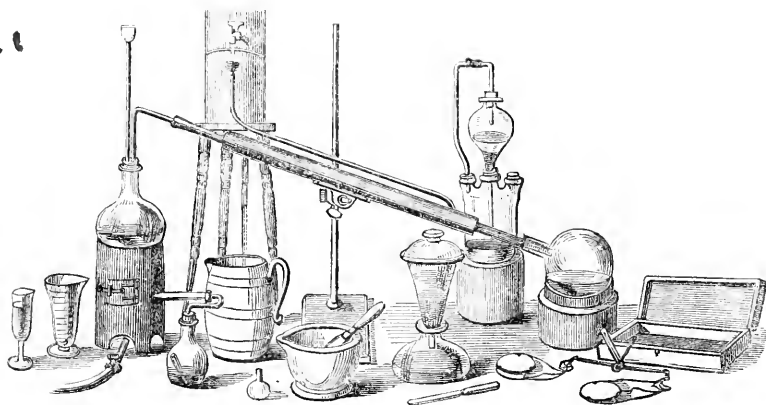
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PRACTICAL PHARMACY:

THE ARRANGEMENTS,
APPARATUS, AND MANIPULATIONS,
OF THE
PHARMACEUTICAL SHOP AND LABORATORY.

BY
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AND
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PROFESSOR OF CHEMISTRY AND PHARMACY TO THE PHARMACEUTICAL SOCIETY
OF GREAT BRITAIN.

EDITED, WITH EXTENSIVE ADDITIONS,
BY
WILLIAM PROCTER, JR.,
PROFESSOR OF PHARMACY IN THE PHILADELPHIA COLLEGE OF PHARMACY.

ILLUSTRATED BY FIVE HUNDRED ENGRAVINGS ON WOOD.



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PREFACE BY THE EDITOR.

IN presenting the work of Mohr and Redwood to the American Pharmaceutical Public, it is under the impression that the want of a treatise on the apparatus and manipulations of Practical Pharmacy has long been felt. The Practice of Pharmacy as conducted in England and in the United States is sufficiently alike, to render this work appropriate as a handbook for the American Apothecary; and the eminence of the authors in their respective countries, is a guarantee of the value of the information it contains. In passing through the hands of the Editor, the book has been increased more than one-fourth in size, about one hundred wood-cuts have been added, the arrangement of the subjects materially changed, and the work divided into chapters, each of which includes either one distinct subject, or several that have a certain generic relation to each other. One object sought by the change of arrangement has been to fit the work as a text-book for the Editor's class in the Philadelphia College of Pharmacy, as far as its nature will admit, and some of the additions have been made with a view to the same object. Although the relative position of the subjects has been altered, the Editor has endeavoured, as far as possible, to leave their integrity undisturbed. The principal changes will be observed in the chapters on Heating Arrangements, Solution, and Evaporation, which, whilst all of the original has been retained, have been materially extended. Nearly the whole of Chapter XII. is new, and is intended to fill a hiatus in reference to several important operations in Pharmaceutical Chemistry. The fourteenth chapter is entirely new, embracing the manipulations required by the fatty substances and

the several classes of preparations derived from them. The last chapter may be looked upon as an appendix. That part relating to reagents is added, not that it is deemed essential to a treatise on Practical Pharmacy, but as presenting information of great value to the pharmacist. An apology is perhaps due from the Editor, for the numerous additions interspersed through the chapters; but he can only say, that in no instance has the mere desire to add influenced him in the task. In the English edition the portion contributed by Mr. Redwood constitutes about two-thirds of the entire work, and is distinguished by being enclosed in brackets. The American publishers, in directing the omission of these, have had no intention of injustice to either author; their sole reason has been to avoid the patched appearance occasioned by so many brackets in addition to those necessarily requisite for the American matter, which is enclosed with the initials W. P. It may be stated, however, that the contributions of Mr. Redwood embrace nearly the whole of Chapter I., including the remarks on heating, lighting, and ventilation; the whole of Chapter II.; observations on gas-burners and furnaces, in Chapter III.; the pharmaceutical stove and steam apparatus for the laboratory, in Chapter IV.; the whole subjects of the pulverization of drugs and the granulation of metals, in Chapter V.; nearly the whole of Chapters VI. and VII.; the hydraulic press, in Chapter VIII.; the preparation of tinctures by displacement, in Chapter IX.; nearly the entire Chapter X.; two-thirds of Chapter XI., including the interesting remarks on the cohesive and adhesive forces of liquids; the latter portion of Chapter XIII., relative to Woulf's apparatus and furnace hoods; about half of Chapter XV., including the removal of glass stoppers and coating glassware with copper; and finally, nearly the whole of the two important chapters on Extemporaneous Pharmacy, with the exception of the section on spreading plasters. Dr. Mohr's more special contributions are, furnace operations, in Chapter III.; the Beindorf's apparatus, in Chapter IV.; coarse comminution, in Chapter V.; nearly the whole of Chapter VIII.; Count Real's press, and aqueous displacement, in Chapter IX.; the drying-closet, in Chapter X.; the first third of

Chapter XI. ; the subject of sublimation, in Chapter XII. ; the first half of Chapter XIII. ; half of Chapter XV., including the stoppering of glass bottles and glass-working. In many parts the labours of the authors are so intermingled that a notice of this kind is inadequate to distinguish them. It should be stated, however, that some parts that have been attributed to Mr. Redwood are indirectly due to Dr. Mohr, but are incorporated with the observations of the former, due credit being given. The index and table of contents have been much enlarged, and a list of the illustrations added.

In reference to the mechanical execution of the book, the Editor may be allowed to allude with undisguised pleasure, both as relates to the engravings and the typography.

W. P., JR.

Philadelphia, April, 1849.

P R E F A C E.

A WORK on Practical Pharmacy, embracing a Description of Apparatus and Manipulations, has long been considered a desideratum in this country, and I have repeatedly been urged by members of the Pharmaceutical Body to undertake the preparation of such a work. The pressure of other engagements, however, prevented my doing so, until an opportunity was presented, by the appearance of Dr. Möhr's "Manual of Pharmaceutical Technology," for laying before the English reader the "results of the personal experience" of one of the most eminent of the continental pharmacutists. Under these circumstances, I undertook to edit a translation of those parts of Dr. Möhr's book which might be thought to convey the most practically useful information, and to make such additions as would meet the requirements of English Pharmaceutical Chemists. In proceeding with this undertaking, it was found necessary to make much more extensive additions of new matter, and alterations in that taken from the German, than had in the first instance been contemplated. This may be ascribed to the fact, that the circumstances by which the pharmacutists are surrounded, in England and in Germany, are very different; and that, therefore, the arrangements provided and suitable in the one case, are, in many respects, inapplicable to the other. The original matter which has been introduced, including upwards of one hundred and sixty of the engravings, constitutes about two-

thirds of the volume, and this is enclosed within brackets [], to distinguish it from that which has been translated.* It is due, however, to the German author to state, that a faithful translation has not, in any part, been attempted, the paramount object having been to suit the matter to the wants of those for whom it is designed.

T. R.

19 Montague Street, Russell Square,
December. 1848.

* See explanation in the American preface.

CONTENTS.

CHAPTER I.

GENERAL ARRANGEMENTS, - - -	17
Shop or dispensary, - - -	17
Arrangements for heating, - -	19
“ “ lighting, - - -	22
“ “ ventilating, - - -	24
Division of shop into compartments,	27
The dispensing counter, - - -	28
Laboratory, - - -	34
Store-room, - - -	35
Store-cellar, - - -	36
Drying-room loft, - - -	36
Powdering-room, - - -	37

CHAPTER II.

WEIGHING AND MEASURING, AND THE DE- TERMINATION OF SPECIFIC GRAVITIES, -	38
Weights, - - -	39
Balances, - - -	40
Balance cases, - - -	44
Weighing, - - -	47
Measuring, - - -	49
Tables of weights, - - -	50
Tables of measures, - - -	54
Methods of determining the specific gravity of solids, - - -	56
Method of ascertaining the specific gravity of liquids by weighing, -	60
By hydrometers, - - -	61
By specific gravity syphon, -	73
Hydrometer tables, - - -	73

CHAPTER III.

ON THE SOURCES AND MANAGEMENT OF HEAT, - - -	75
FURNACE OPERATIONS, - - -	75
Fuel, - - -	76

Crucibles, - - -	78
Air or wind furnaces, - - -	80
Blast-furnaces, - - -	83
Double bellows, - - -	84
Crucible furnace, - - -	85
Seftstroem's furnace, - - -	86
Common blast-furnace, - - -	88
Centrifugal blower, - - -	89
Flame-furnace, - - -	91
Section of flame-furnace, - - -	92
Common portable furnaces, -	92, 93
GAS AND ALCOHOL LAMPS, - - -	94
Wire gauze gas-burners, - - -	95
Gas-burners, - - -	95
Gas-furnaces, - - -	96
Alcohol lamps, - - -	97
Syringe blowpipe, - - -	100
Mouth blowpipes, - - -	101
Thermometers, - - -	102
Thermometrical table, - - -	104
Effects of temperature, - - -	106

CHAPTER IV.

ON STEAM HEATING APPARATUS, AND ITS APPLICATIONS TO THE PURPOSES OF	
PHARMACY, - - -	107
Beindorf's apparatus, - - -	107
Boiler, - - -	108
Cucurbit and head, - - -	108
Evaporating pans, - - -	109
Steam-funnel, - - -	109
Hot air chamber, - - -	110
Condensing tube, - - -	113
Kolle's condenser, - - -	114
Gadda's condenser, - - -	114
Mitscherlich's condenser, - - -	115
Distillation with Beindorf's appa- ratus, - - -	116
Digestion and infusion, - - -	118

Solution and liquefaction, - -	119
Saponification, &c., - -	119
Vaporization, - -	119
Mechanical stirrer, - -	120
Laboratory alarum, - -	123
Redwood's pharmaceutical stove, -	125
Water joint, - -	126
Furnace hood, - -	127
Steam boilers, - -	129
Steam apparatus for laboratory, -	135
Ventilation of laboratory, - -	139

CHAPTER V.

COMMINATION, - - - -	140
COARSE COMMINATION OF VEGETABLE SUB-	
STANCES, - - - -	140
Chopping trough, - -	141
Cutting or slicing knife, -	142
Self-supplying knife, - -	144
Cradle knife, - -	145
Rolling knife, - -	145
Chinese cutting trough, -	145
PULVERIZATION, - - - -	146
Contusion, - - - -	146
Mortar and spring pestle, - -	147
Stampers, - - - -	148
Trituration, - - - -	153
Marble mortars, - - - -	153
Porphyry slab and muller, - -	155
Levigating apparatus, - -	155
Drug mill, - - - -	158
Drug grinding, - - - -	159
Sifting apparatus, - - - -	160
GRANULATION OF METALS, - - - -	170
Granulating box, - - - -	171
Elutriation, - - - -	173

CHAPTER VI.

DECANTATION AND WASHING, - -	174
Decantation with a guiding rod, -	175
over a greased rim, - -	176
Syphons, - - - -	177
Pipettes, - - - -	184

CHAPTER VII.

FILTRATION, - - - -	187
Filtering media, - - - -	187

Construction of cloth filters, - -	190
Vacuum filter, - - - -	193
Funnels, - - - -	194
Construction of paper filters, - -	195
Air-tight filtering, - - - -	199
Hot filtering, - - - -	200
Continuous filtering, - - - -	201
Washing precipitates, - - - -	206
Wash-bottles, - - - -	207
CLARIFICATION, - - - -	208
DECOLORATION, - - - -	210
Animal charcoal, - - - -	210
Charcoal filter, - - - -	211

CHAPTER VIII.

THE PRESS, - - - -	213
Horizontal press, - - - -	215
Vertical press, - - - -	220
Hydraulic press, - - - -	229
Wedge press, - - - -	231
PROCESS OF EXPRESSION, - - - -	232
Press bags, &c., - - - -	233

CHAPTER IX.

SOLUTION, - - - -	235
Principles of solution, - - -	235
Pharmaceutical menstrua, - -	236
Modes of solution, - - - -	237
Circulatory displacement, - -	238
Table of solubilities, - - - -	239
Maceration, - - - -	245
Infusion, - - - -	245
Infusion pots, - - - -	245
Digestion, - - - -	246
Decoction, - - - -	247
Displacement, - - - -	247

ON THE PREPARATION OF SOLUTIONS FOR

EXTRACTS AND SYRUPS, - - - -	248
Solutions for aqueous extracts, -	248
Mohr's press for extractions, -	251
Count Real's filter press, - -	252
Aqueous displacement, - - - -	255
Smith's steam displacer, - - -	260

SOLUTIONS FOR ETHEREAL AND ALCOHOLIC

EXTRACTS AND TINCTURES, - - -	262
Mohr's apparatus for ethereal tinc-	
tures, - - - -	264

By maceration, (Pharmacopœia process,) - - - - -	266
By maceration, (Dr. Burton's process,) - - - - -	267
By displacement, - - - - -	268
Displacement apparatus, -	270-272
Tinctures, - - - - -	277
Preserved juices, or alcoolatures, -	278
Medicated wines, - - - - -	279
Medicated vinegars, - - - - -	279
Oily solutions, - - - - -	279
Saccharine solutions, Syrups, -	280
Preparation of simple syrup, -	280
Medicated syrups, - - - - -	282
Syrups of vegetable juices, -	283
Mellites, - - - - -	284

CHAPTER X.

EVAPORATION, - - - - -	286
Objects of vaporization, -	286
Principles of evaporation, -	286
Evaporation over the naked fire, -	287
Evaporation of solutions for extracts, - - - - -	288
By the water-bath, - - - - -	290
By the steam-bath, - - - - -	291
In vacuo, - - - - -	293
Redwood's apparatus for extracts, - - - - -	294
Vacuum apparatus, - - - - -	297
Spontaneous evaporation, - - - - -	298
Drying-closets, - - - - -	300
Blowing apparatus, - - - - -	306
Pugging mill, - - - - -	307
General hints on the classification and preparation of extracts, -	308
Consistence of extracts, - - - - -	310
Fluid extracts, - - - - -	311

CHAPTER XI.

DISTILLATION, - - - - -	312
Retorts, - - - - -	313
Receivers, - - - - -	315
Arrangement for apparatus, -	317
Refrigeration, - - - - -	321
Condensers, - - - - -	323
Application of heat, - - - - -	324
Flasks, - - - - -	325

Retort-stand, - - - - -	326
Process of distillation in glass vessels, - - - - -	329
Distillation of oil of vitriol, - -	336
Distillation of hydrocyanic acid, -	341
Pharmaceutical still, - - - - -	345
Stoneware still, - - - - -	346
Stoneware condenser, - - - - -	347
Distillation of waters and essential oils, - - - - -	356
Rectification of ether, - - - - -	367

CHAPTER XII.

SUBLIMATION, - - - - -	360
Sublimation of benzoic acid, -	360
" of calomel, - - - - -	362
" corrosive sublimate, -	364
TORREFACTION, - - - - -	366
DESTRUCTIVE DISTILLATION, - - -	367
INCINERATION, - - - - -	368
CALCINATION, - - - - -	368
Calcination of magnesia, - -	369
FUSION, - - - - -	370
REDUCTION, - - - - -	370
OXIDATION, - - - - -	371
CRYSTALLIZATION, - - - - -	373
By sublimation, - - - - -	373
By fusion and partial cooling, -	373
From solutions, - - - - -	374
PRECIPITATION, - - - - -	377
NEUTRALIZATION, - - - - -	381
Test-papers, - - - - -	381
Alkalimetry, - - - - -	382
Acidimetry, - - - - -	383

CHAPTER XIII.

GENERATION AND ABSORPTION OF GASES, -	386
Carbonic acid, - - - - -	386
Sulphuretted hydrogen, - - -	391
Hydrogen, - - - - -	393
Reduction by hydrogen, -	394
Reduction of iron by hydrogen, -	395
Chlorine, - - - - -	396
Ammonia, - - - - -	398
Generating vessels and wash-bottles, -	400
Safety-tubes, - - - - -	401
Woulf's apparatus, - - - - -	402
Escape of noxious gases, - -	405

CHAPTER XIV.

GENERAL OBSERVATIONS ON THE PREPARATION OF THE FIXED OILS AND FATS EMPLOYED IN PHARMACY, - - -	408
By expression, - - -	408
By boiling, - - -	409
By solution, - - -	410
Decoloration of fixed oils, - - -	441
CERATES, - - -	412
OINTMENTS, - - -	414
Ointments by mixing, - - -	414
" by solution, - - -	416
" by chemical reaction, - - -	417
SAPONIFICATION, - - -	418
Soaps, - - -	418
Plasters, - - -	419
Shoemaker's apparatus for making lead plaster, - - -	420

CHAPTER XV.

MISCELLANEOUS OPERATIONS, CHIEFLY MECHANICAL, - - -	423
Stoppering of glass bottles, - - -	423
Removal of fixed stoppers, - - -	424
Desiccation of bottles, flasks, &c., - - -	428
Tying of knots, - - -	429
The capping knot, - - -	429
The binding knot, - - -	430
The pyrotechnical knot, - - -	431
Champagne knots, - - -	433
Working in glass, - - -	435
Cutting, - - -	435
Drilling, - - -	438
Bending, - - -	441
Glass-blower's blowpipe, - - -	442
Sealing tubes, - - -	444
Joining tubes, - - -	445
Graduation of glass vessels, - - -	448
Connecting and luting apparatus, - - -	450
India-rubber connectors, - - -	450
Cork borers, - - -	451, 452
Tube connexions, - - -	453
Metallic tube connexions, - - -	454
Coating of glass vessels with copper, - - -	456
Preparation of waxed paper, - - -	458
Casting of zinc, potash, and lunar caustic, - - -	459
Closed operating chamber, - - -	461

CHAPTER XVI.

EXTEMPORANEOUS PHARMACY, - - -	463
Means of preserving cleanliness, - - -	465
Aids to dispensing, - - -	466
Infusions and decoctions, - - -	470
Reading the prescription, - - -	475
Explanation of Latin abbreviations, - - -	478
Preparation of mixtures, - - -	484
Draughts, - - -	486
Drops, - - -	488
Emulsions, - - -	488
Powders, - - -	492
Electuaries, - - -	494
Conserves, - - -	494
Linctus, - - -	494
Lozenges, - - -	495
Pastes, - - -	496

CHAPTER XVII.

EXTEMPORANEOUS PHARMACY, - - -	497
Preparation of pills, - - -	497
Capsules, - - -	510
Gargles, injections, &c., - - -	514
Lotions, liniments, &c., - - -	514
Ointments, - - -	514
Suppositories, - - -	515
Cataplasms, - - -	515
Moxas, - - -	516
Spread plasters, - - -	517
Machines for spreading plasters, - - -	524
Inhalation, - - -	532
Gases, - - -	532
Vapours, - - -	536
Ether, - - -	536
Chloroform, - - -	539
Fumes, - - -	540
" of opium, - - -	540

CHAPTER XVIII.

APPARATUS FOR TESTING, - - -	542
List of reagents, - - -	543
Directions for ascertaining the purity of reagents, - - -	544
Tables, - - -	561

LIST OF ILLUSTRATIONS.

Mixed gas furnace, - - - -	20	Hessian crucible, - - - -	78
Redwood's pharmaceutical stove, -	21	Porcelain crucible, - - - -	78
Interior of shop and gas-lighting, -	23	Platinum crucible, - - - -	78
Faraday's gas-lamp, - - - -	24	Air-furnace, - - - -	81
Dr. Arnott's ventilating valve, - -	25	Double bellows, - - - -	84
Japanned canister for herbs, - -	28	Crucible furnace, - - - -	85
Dispensing counter, - - - -	29	Seftstroem's furnace, - - - -	86
Drawer, cork-presser and roller, -	31	Common blast-furnace, - - - -	88
Pill machine, - - - -	32	Centrifugal blower, - - - -	89
Twine-boxes, - - - -	33	Flame-furnace, - - - -	91
Cork-squeezer, - - - -	33	Section of flame-furnace, - - - -	92
Powder-folder and bottle-stoop, - -	33	Common portable furnace, - - - -	92
Root-cutting knife, - - - -	34	Portable charcoal furnace, - - - -	94
Laboratory shelving, - - - -	34	Solid gas-flame, - - - -	95
Long root-cutting knife, - - - -	35	Ring gas-burners, - - - -	96
Store-room boxes, - - - -	35	Gas-furnace, - - - -	96
Mortar and spring pestle, - - - -	37	Mitchell's alcohol lamp, - - - -	97
Steelyard, - - - -	42	Berzelius's alcohol lamp, - - - -	98
Scales and case, - - - -	43	Lamp chimney, - - - -	98
Balance and case, - - - -	44	Glass alcohol lamp, - - - -	99
Balance-case, - - - -	45	Cooper's lamp-furnace, - - - -	99
Minim-meter, - - - -	46	Mitchell's retort-stand, - - - -	100
Glass syringe, - - - -	48	Redwood's gas blowpipe, - - - -	100
Method of holding the balance, - -	48	Syringe blowpipe and table, - - - -	101
Method of holding the measure-glass, -	49	Mouth blowpipes, - - - -	101
Apparatus for taking specific gravities,	57	Blowpipe flame, - - - -	102
Specific gravity bucket, - - - -	59	Boiler of Beindorf's apparatus, - - - -	103
Specific gravity bottle, - - - -	60	Cucurbit and head, - - - -	103
Common hydrometer, - - - -	63	Evaporating pan, - - - -	109
Specific gravity bead, - - - -	65	Still head and steam-funnel, - - - -	109
Gay-Lussac's alcoholometer, - - - -	65	Hot air chamber, - - - -	110
Sikes's hydrometer, - - - -	66	Boiler-gauge, - - - -	110
Saccharometer, - - - -	69	Section of Beindorf's apparatus, - - - -	111
Urinometer, - - - -	69	Beindorf's condensing tube, - - - -	113
Elaëometer, - - - -	69	Common worm-tub, - - - -	114
Specific gravity cone, - - - -	70	Kolle's condenser, - - - -	114
Apparatus for taking specific gravities,	71	Gadda's condenser and still, - - - -	114
Specific gravity syphon, - - - -	73	Mitscherlich's condenser, - - - -	115

Beindorf's complete apparatus, - -	116	Separator for volatile liquid, - -	186
Distillation with steam-funnel and		Mitchell's separator, - - -	186
Mohr's condenser, - - -	118	Pipette for bromine, etc., - - -	186
Mechanical stirrer, - - -	121	Conical filter-bag and support, - -	190
Laboratory alarm, - - -	123	Frame filter, - - -	191
Pharmaceutical stove, - - -	125	Taylor's filter, - - -	192
Water-joint, - - -	126	Vacuum filter, - - -	193
Furnace hood, - - -	127	Well-formed funnel, - - -	194
Section of pharmaceutical stove, -	128	Porcelain funnel, - - -	195
Section of steam boiler, - -	129, 130	Filter support, - - -	195
Shoemaker and Small's boiler, -	132	Plain filter, - - -	195
Steam apparatus for laboratory, -	135	Filter pattern, - - -	196
Mechanical stirrer, - - -	138	Modified plain filter, - - -	196
Steam jets, - - -	139	Plaited filter, - - -	197, 198
Steam jet ventilator, - - -	139	Plain filter with doubled point, -	198
Chopping trough, - - -	141	Air-tight filter - - -	199
" knives, - - -	141	Water-bath funnels, - - -	200
Cutting or slicing knife, - - -	142	Donovan's filter, - - -	201
Blade of " " - - -	143	Arrangements for continuous filtering,	
Mohr's self-supplying knife, - -	144		203, 205
The cradle knife, - - -	145	Washing precipitates, - - -	206
The rolling knife, - - -	145	Wash-bottles, - - -	207
Chinese cutting trough, - - -	145	Wash-bottle for hot water, - - -	208
Mortar and spring pestle, - - -	147	Charcoal filter for decolorizing, -	211
Cover for mortar, - - -	149	Double screw or horizontal press, -	215
Dusting bags, - - -	150	Section of do., - - -	216
Apparatus for powdering drugs, -	151	Lever for press, - - -	218
Swift's drug mill, - - -	152	Iron plate for hot pressing, - - -	219
Marble mortar for trituration, -	153	Wooden screw or vertical press, -	221
Porphyry slab and muller, - - -	155	Pressing box, - - -	222
Levigating vessel, - - -	155	Single screw or vertical press, -	223
Spring pestle for levigation, - -	156	Section of vertical press, - - -	225
Spring for levigating apparatus, -	157	Illustration of the principle of the hy-	
Conical mould for levigated chalk, etc.,	157	draulic press, - - -	227
Apparatus for drug grinding, - -	158	Bramah's hydraulic press, - - -	229
Stamper tilt, - - -	159	Section of hydraulic press, - - -	230
Sifting apparatus, - - -	160	Wedge press, - - -	231
Granulating box, - - -	171	Solution in flasks, - - -	236
Decantation with a guiding rod, -	175	Solution in capsules, - - -	238
Decantation over a greased rim, -	176	Apparatus for dissolving crude soda, -	239
Syphon, - - -	177	Squire's infusion pot, - - -	245
Syphon illustrated, - - -	178	Alsop's infusion mug, - - -	245
Lateral tube syphons, - - -	180	Mohr's ether digester, - - -	246
Metallic syphon, - - -	181	Soubiran's ether digester, - - -	246
Platina syphon, - - -	182	Mohr's press for extractions, - -	251
Negretti's syphon, - - -	182	Count Real's press by Mohr, - - -	253
Syphons, - - -	183	Section of Real's press, - - -	254
Pipettes, - - -	184	Displacement cones, - - -	259
Washing pipettes, - - -	185	Smith's steam displacer, - - -	260
Separating funnel, - - -	186	Mohr's apparatus for ethereal tinctures,	264

Displacers for tinctures, - - -	270	Safety-tube, - - - - -	341
Gilbertson's displacer, - - -	270	Wohler's apparatus, - - - -	342
Displacer for volatile liquids, - -	272	Furnace and sand-pot for distillation,	
Glass displacers, - - - -	272	with a retort, - - - -	343
Continuous displacement, - - -	272	Retort in sand-pot, - - - -	344
Saccharometer cup, - - - -	281	Portable furnace for distillation, -	344
Syrup filter for small quantities, -	281	Pharmaceutical still, - - - -	345
Water-bath, - - - -	291	Stoneware still, - - - -	346
Redwood's apparatus for preparing ex-		Stoneware condenser, - - - -	347
tracts in vacuo, - - - -	294	Still and condenser, - - - -	349
Vacuum apparatus, - - - -	297	Cucurbit and false bottom, - - -	350
Heating box for Mohr's drying-closet, -	301	Florentine receiver, - - - -	351
Mohr's drying-closet, - - - -	302	Oil separator, - - - -	351
Apparatus for spontaneous evaporation,	303	The rouser, - - - -	354
Section of stove, - - - -	304	Oil separator, - - - -	354
Drying oven, - - - -	305	Oil separators, - - - -	355
Blowing machine, - - - -	306	Graduated oil separator, - - -	356
Pugging mill, - - - -	307	Ether condenser, - - - -	359
Well-formed retort, - - - -	313	Apparatus for subliming benzoic acid, -	361
Badly formed retort, - - - -	314	Apparatus for subliming calomel and	
Well-formed tubulated retort, - - -	314	corrosive sublimate, - - - -	364
Badly formed tubulated retort, - - -	315	Apparatus for subliming calomel in	
Tubulated receiver, - - - -	315	powder, - - - -	365
Quilled receiver, - - - -	316	Apparatus for destructive distillation, -	367
Process of distillation, - - - -	316	Furnace for calcining magnesia, - -	369
Furnace for distillation, - - - -	317	Apparatus for preparing anhydrous phos-	
Method of charging a plain retort, -	318	phoric acid, - - - -	372
Retort funnel, - - - -	318	Crystallization of sulphur, - - -	374
Retort in a sand-bath, - - - -	319	Apparatus for preparing heavy carbonate	
Adapters, - - - -	321	of magnesia, - - - -	380
Retort neck refrigeration, - - - -	321	Alkalimeter, - - - -	383
Retort with receiver and adapter, -	321	Carbonic acid apparatus, - - -	387, 390
Apparatus for distillation, - - - -	322	Sulphuretted hydrogen apparatus, -	393
Capped retort, - - - -	322	Dr. Hare's hydrogen generator, - -	393
Liebig's condenser, - - - -	323	Apparatus for reducing metallic oxides	
" " glass, - - - -	324	by hydrogen, - - - -	394
Gas-furnace and flask for distillation, -	325	Apparatus for reducing oxide of iron by	
Flask and sand-bath, - - - -	325	hydrogen, - - - -	395
Copper-coated flask, - - - -	325	Apparatus for chlorine, - - - -	396
Retort-stand, with Gay-Lussac's holder		Apparatus for bleaching sponge, - -	397
and Liebig's condenser, - - -	326	Apparatus for generating ammonia, -	398
Refrigerating cistern, - - - -	327	Gas bottles, - - - -	400
Arrangement for distillation, - - -	328	Generating bottles, - - - -	401
Apparatus showing the forces of cohesion		Welter's safety-tube, - - - -	402
and adhesion in oil of vitriol, -	332	Woulf's apparatus, - - - -	402
Apparatus exhibiting the forces of cohe-		Furnace hoods, - - - -	406
sion and adhesion in water, - - -	333	Mortar for mercurial ointment, - -	416
Distillation of oil of vitriol, - - -	336, 337	Shoemaker's apparatus for preparing lead	
Small plated still, - - - -	338	plaster, - - - -	420
Apparatus for distillation, - - - -	339	Stoppering glass bottles, - - - -	424

Lever for removing fixed stoppers, -	425	Coating vessels with copper, -	456, 457
Extraction of fixed stoppers, -	427	Mould for casting zinc, -	460
The capping knot, -	430	Mould for casting potash and lunar	
The binding knot, -	431	caustic, -	460
The pyrotechnical knot, -	432	Closed operating chamber, -	463
The beer knot, -	432	Decoction saucepan, -	471
The champagne knot, -	433	Beindorf's decoction press, -	473
Iron ring for cutting glass, -	435	Prescription stand, -	477
Arrangement for cutting glass, -	436	Powder-folder, -	494
Cutting glass with ac harcoal point, -	437	Apparatus for analysing blue mass, -	505
Drill for boring glass, -	439	" " making blue mass, -	505
Tube patterns, -	439	Water-bath for gelatin, -	509
Solid gas flame, -	440	Coating pills with gelatin, -	509
Alcohol lamp for tubes, -	440	Capsule mould, -	510
Bent tubes, -	441	Preparation of capsules, -	511
Glass-blower's blowpipe table, -	442	Filling capsules, -	512
Bellows for " " -	442	Patterns of plasters, -	517, 518
Water blowpipe, -	443	Plaster spatulas, -	519
Method of using water blowpipe, -	443	Apparatus for spreading plasters, -	524
Sealing tubes, -	444	Plaster knife, -	526
Widening tubes, -	445	Apparatus for spreading plasters, -	527, 528
Joining tubes, -	445	Section of plaster knife, -	529
Blowing bulbs, -	446	Inhaler, -	535
Gas blowpipe, -	447	Ether inhaler, -	536, 537
Glass graduating arrangement, -	449	Chloroform inhaler, -	539
Gum elastic connectors, -	450	Apparatus for smoking opium, -	540
Cork borers (German), -	451	Test-tubes and rack, -	542
Cork borers (English), -	452	Apparatus for sulphuretted hydrogen -	547
Tube connexions, -	453-455		

PRACTICAL PHARMACY.

CHAPTER I.

ON THE GENERAL ARRANGEMENTS OF THE SHOP, LABORATORY, ETC.

THE business of a CHEMIST AND DRUGGIST, or PHARMACEUTIST, involves a variety of operations and arrangements, for which several apartments are required and should be specially appropriated. A well-appointed pharmaceutical establishment ought to comprise,—

The Shop or Dispensary,	Store-cellar,
Laboratory,	Drying-room or loft, and
Store-room,	Powdering-room.

THE SHOP OR DISPENSARY.—This is the most essential and important apartment in the establishment,—that in which the Pharmaceutist must contemplate spending a great part of his time, and where he hopes to be often actively engaged in the bustle of business. The success of his undertaking as a man of business cannot fail to depend, in some measure, on the adaptation of this apartment to the purposes for which it is intended.

In selecting, arranging, and fitting up the shop, provision should be made, to the greatest extent practicable, for promoting the health, comfort, and convenience of its daily occupants, and the preservation from injury of the drugs and preparations intended to be kept in it.

The form that appears to be best suited for the shop of a Pharmaceutical Chemist is an oblong, one of the short sides of which forms the front, as it is desirable to have long, straight walls, giving depth rather than width to the apartment. It should be dry and well lighted, yet not too much exposed to the direct rays of the sun. Large windows, therefore, are objectionable; they are not required for the display of pharmaceutical wares, while they occasion a great deal of trouble in keeping them clean, and admit more direct sunlight than is beneficial.

The opinion very generally prevails among Pharmacutists, that the shop should have a north aspect, or at least that direct sunshine should be entirely excluded; but I have no hesitation in expressing my dissent from this opinion.

The entrance to the shop ought not to be directly from the street, but from the passage to the house. There are several objections to having the entrance directly from the street: it occasions the admission of wind, dust, and wet, when the door is opened, and renders it difficult to regulate the temperature of the room, and insure the comfort and freedom from unnecessary disturbance of those engaged in conducting the business.

In free-trade England, however, it is generally considered desirable to make the access to the shop as easy and obvious as possible. I have heard calculations made, by some approved economists, to show the loss a tradesman sustains in consequence of his shop-floor being elevated too much above the level of the street, thus rendering it necessary for customers to ascend two or three steps on entering. One step, if it be a low and easy one, is considered beneficial, the advantage resulting from the exclusion of wet and dirt being more than equivalent to the obstruction it imposes on the facility of admission; but every step beyond this is calculated to involve a loss to the owner of the shop. A good economist will also be careful to provide easy means for opening and shutting the shop-door: an imperfect latch or inconvenient handle to the door, by occasioning annoyance to the customer, becomes a source of injury to the tradesman.

Among the arrangements connected with the fitting of the shop, there are none more important in their influences on the health and comfort of the inmates, than those by which provision is made for *heating, lighting, and ventilating* the apartment. No pains should be spared in rendering the means for effecting these objects as complete and perfect as possible. The expense incurred will be a profitable investment, if it insures the complete fulfilment of the objects proposed, by making the place of business a fit place for healthful recreation, instead of being, as it too often is, an imperfectly-heated and badly-ventilated apartment, where body and mind are benumbed with cold or oppressed with vitiated air. Are there not many, both employers and employed, whose longings to be released from the restraints of business occupations may be traced, at least in part, to these atmospheric influences?

One of the first questions to be settled, therefore, in connexion with the fitting of the shop, should be,—what are the best means for regu-

lating the heat, light, and ventilation of the apartment? It is desirable that these means should be planned and finally arranged in connexion with the other fittings of the shop, so that they may be made subservient to each other. No plan that could be proposed for effecting these objects would be equally applicable in all cases, differences in the size and construction of apartments rendering that which may be suitable in one case inapplicable in another. The following suggestions, however, may probably prove useful under a variety of circumstances.

Arrangements for Heating the Shop.—It is desirable that the means adopted for this purpose should be economical and efficient when used, and that their disuse should involve no inconvenience; for there are only a few months in the year during which artificial heat is required in the shop.

The most common arrangement for warming shops consists in the use of a stove fixed near the centre of the room. In these cases the flue is sometimes made to descend, and is then carried underneath the ceiling of the room below until it reaches the chimney. The heat is communicated to the atmosphere both by radiation, and by conduction from the contact of air with the heated surface of the stove. If the stove be much heated, as is the case with common stoves of this kind, a disagreeable flavour is sometimes communicated to the air, in consequence of the decomposition or volatilization of organic matter, either floating in the atmosphere or otherwise brought in contact with the hot metal. Dr. Arnott's stoves, which never become heated to a very high temperature, are not subject to this objection, and are at the same time economical and efficient.

Gas stoves are occasionally used for warming shops. A patent has been taken out by Mr. Rickets for a stove of this kind which requires no chimney. It consists of an external cylindrical case, within which gas jets are ignited, and these are made to heat a number of tubes fixed within the stove, through which air passes. The heat, however, is principally diffused by radiation.

These stoves are objectionable if used without a chimney, on account of their adding the carbonic acid, and other noxious products of the combustion of the gas, to the atmosphere of the room.

There is another kind of gas-stove or furnace, fitted up by Mr. Rickets and other gas-fitters, which although not generally used expressly for heating rooms, may, in some cases, in addition to its application to other useful purposes, be made available for warming a small shop.

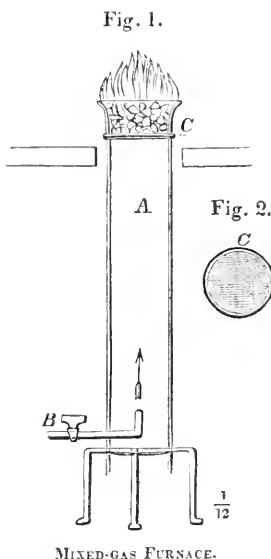
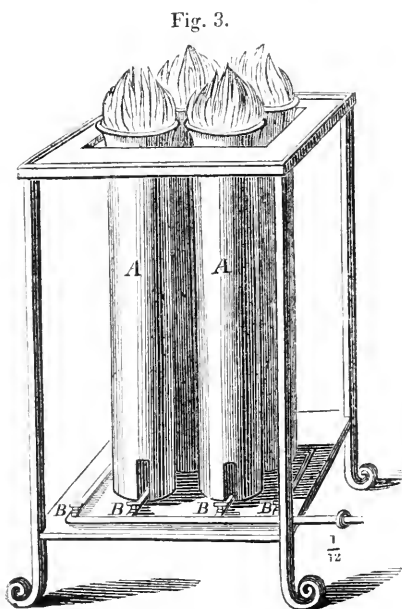


Fig. 1, represents a section of one of these furnaces. A, is an iron tube, about two feet long and two, three, or four inches in diameter, open at both ends. At C, about two inches from the top, a disk of fine wire gauze (fig. 2) is securely fixed, so as to form a diaphragm, on which are put some pieces of broken pumice-stone to fill the upper part of the tube. B, is a gas-pipe from which gas is allowed to escape into the tube A, where, on ascending, it mixes with the atmospheric air, which has free ingress at the bottom. This mixture of gas and air, passing through the wire gauze, is ignited on the surface of the pumice-stone. The wire gauze is used to prevent the communication of the ignition

to the combustible mixture below it, while the pumice-stone, becoming



red-hot, forms a good radiating surface. The quantity of gas admitted into the tube A, should be such, that the gaseous mixture shall burn with a pale blue flame *perfectly free from smoke*.

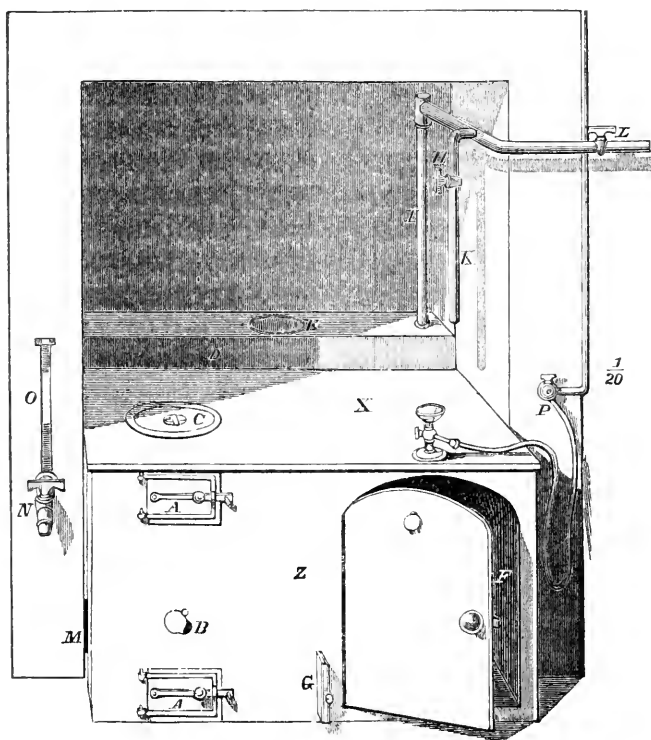
A furnace of this kind may be lighted in an instant; it affords sufficient heat for making a decoction, heating a plaster spatula, or for any other similar purpose; and it occasions no annoyance from dust or smoke. Several of them may be fixed contiguously to each other, as shown in fig. 3, so that two or more may be lighted at the same time, when required, and a great

amount of heat may in this way be produced.

Means ought to be provided for conveying away the products of combustion from this, in common with every other, kind of stove or furnace, instead of allowing them to contaminate the air of the apartment; yet the effects of using either of the gas-stoves above described without a chimney, would not be more injurious than those resulting from the ordinary combustion of the same quantity of gas in lamps.

In some cases a fire-place, already existing in the shop, may be advantageously retained as such, and may have fitted into it, either a common stove, or a close stove having several useful applications, besides that of warming the apartment. Fig. 4, represents a useful

Fig. 4.



PHARMACEUTICAL STOVE.

kind of stove, which may be fixed in the fire-place either of the shop, or more conveniently of a room adjoining the shop, and which will be described in detail in the chapter on the sources and management of heat.

If the pharmaceutical stove be fixed in the shop, there would per-

haps be sufficient heat radiated from the stove itself to impart the required warmth to the atmosphere of the room; but, should this be the case in cold weather, it is obvious that the same diffusion of heat in warm weather would become oppressive and injurious. Yet the stove, if rendered serviceable to the fullest extent of which it is susceptible, should be in daily operation throughout the year. It would be found more convenient, therefore, to have the stove in a separate apartment, contiguous to the shop; or, if this cannot be done, efficient means must be provided for carrying off the heated air, when this is required.

The use of a steam-heating-pipe presents a most unobjectionable method of communicating heat to an apartment. In the case now under consideration, it would only be necessary to have a pipe about three or four inches in diameter, running the entire length of the shop, and fixed in, on, or near to, the floor, with the branch from the pipe L, fig. 4, to supply it with steam from the boiler. This steam-pipe may be made of cast iron, but if one of a suitable size could be obtained, coated on the inside with the enamel now so extensively applied to iron utensils, it would possess this advantage, that the water which would be condensed in it would be available for use as distilled water. The steam pipe should have a little inclination towards the end furthest from the boiler, so that the condensed water may run off from that end into a suitable vessel, fixed for its collection.

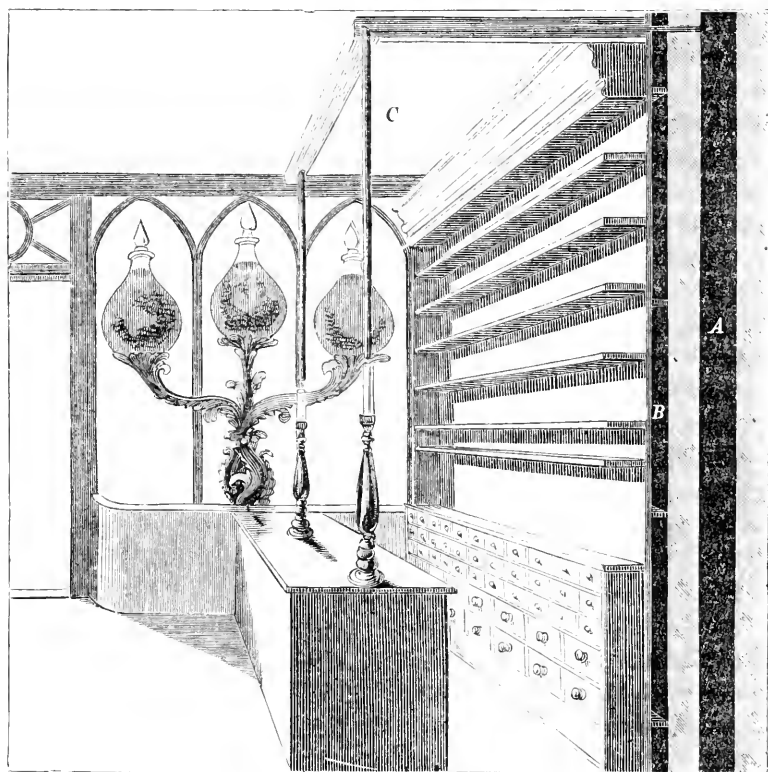
The best position for the steam-heating-pipe would be the space between the floor and the ceiling below, with an iron grating placed over it, or the interior of the counter, with openings to admit of the circulation of air around it. It is calculated that the steam-pipe for heating a room should have one square foot of surface exposed, for every 200 cubic feet of space to be warmed.

[The usual method of heating the shop in our Atlantic cities, is by means of anthracite coal stoves. The condensed form of this fuel renders the use of a large stove unnecessary. Those should be chosen which are cylindrical, the pipe issuing from the side, and a movable top, which may be used as a sand bath, or by its removal will admit of the insertion of the pharmaceutical still, figured in the chapter on distillation, or of an evaporator. An opening with a slide valve should be made in the pipe, eight inches above the top of the stove, for the insertion of tubes and retort beaks, to carry off noxious gases or vapours, during the process of solution or digestion. Indeed, the stove is the source of heat and the laboratory furnace of a large number of shops of limited business.—W. P.]

Arrangements for Lighting the Shop.—Gas is now almost univer-

sally adopted for artificial illumination in our towns. As compared with other means of lighting, it is found to be economical and generally convenient. In the combustion of coal-gas, however, there is a very large amount of heat generated; and, in addition to carbonic acid, there is usually a small quantity of sulphuric or sulphurous acid formed; so that the atmosphere of an apartment, lighted with gas, becomes oppressively hot and injurious to health, unless efficient ventilation, or means for carrying away the products of combustion, be adopted. A plan has been proposed* for conveying the heated and contaminated air from each gas-burner into a chimney, by means of

Fig. 5.



ARRANGEMENTS FOR GAS-LIGHTING AND VENTILATION.

- a. The chimney in the wall of the shop.
- b. The space between the wall and the boarding or wainscot, against which the shelves and drawers are fixed.
- c. Tube conveying products of combustion from the gas-lamp into the chimney.

* On the Importance of Ventilation. By Mr. Squire. *Pharmaceutical Journal*, vol. iv. p. 258.

iron tubes about $1\frac{1}{4}$ or $1\frac{1}{2}$ inch in diameter, extending from the top of the lamp-glass to a horizontal tube, running either between the ceiling and the floor above, or immediately under the ceiling, and communicating with the chimney. This arrangement is shown in fig. 5. Professor Faraday has contrived a very ingenious gas-lamp, by which the same object is effected.

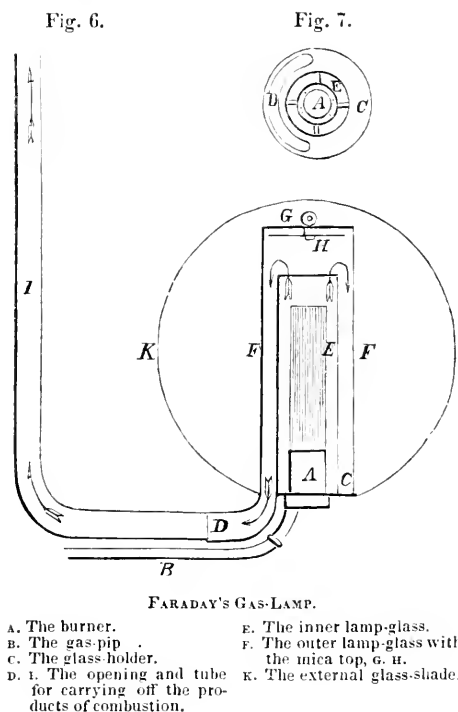
Figs. 6 and 7, represent Faraday's gas-lamp; A, is the burner; B, the gas-pipe leading to the burner; C, the glass-holder, which is best shown in fig. 7; the inner glass E, is a common lamp-glass, which stands on the bars *e*; over this is placed another glass F, of larger dimensions, the top of which is closed by a plate of mica G, or a double plate, as shown in the drawing G, H. From one side of the outer rim of the glass-holder there is an opening D, communicating with the tube I, by which the products of combustion are conveyed away and discharged into a chimney. The glass globe K, having no opening at the top, may be placed over the lamp. The air for supporting the combustion of the

gas enters through the openings in the centre of the burner, and surrounding it, while the products of combustion pass off as shown by the arrows.

It is necessary, on first lighting this lamp, to determine a draught through the tube I, by heating the ascending branch, before the second glass F, is put on; it is also necessary to regulate very carefully the supply of gas, so as to prevent its smoking and blackening the glass.

A patent has been taken out for this contrivance by Mr. Faraday of Wardour Street.

Arrangements for Ventilating the Shop.—Ventilation



consists in the constant removal of that portion of the atmosphere of the apartment which has been rendered impure or unwholesome by

respiration, or in any other way, and the substitution of fresh and wholesome air from without. It is obvious that under ordinary circumstances no portion of air can be removed from a room without an equal quantity being at the same time introduced to supply its place. All means of ventilation, therefore, must provide for the introduction of pure air and the displacement of that which has been contaminated. The principal causes of the contamination of the air in the cases now contemplated, are, respiration and combustion. Air thus contaminated becomes specifically lighter than that by which it is surrounded, and it therefore ascends to the upper part of the room, where provision should be made for its removal. If this be done, fresh air from without will gain admission through the doors and other openings. These, indeed, are the means generally adopted for ventilating apartments; but there is found to be a great impediment to the efficient adoption of these means, arising from the fear of exposure to draughts of cold air, and the difficulty of guarding against this evil.

The two principal points to be considered, therefore, in reference to ventilation, are; 1st, the means by which the vitiated air may be rapidly removed from the upper part of the room; and 2dly, the means for introducing fresh air, which shall be so diffused or previously warmed, as not to occasion the sensation of cold draughts or currents of air.

Dr. Arnott's ventilator affords good and efficient means for the removal of the hot and vitiated air of a room, by allowing it to pass into the chimney. Fig. 8, represents this ventilator, which consists of an oblong metallic frame, A, to be fixed in the wall of the chimney, near the ceiling, as shown in fig. 9.

Fig. 8.

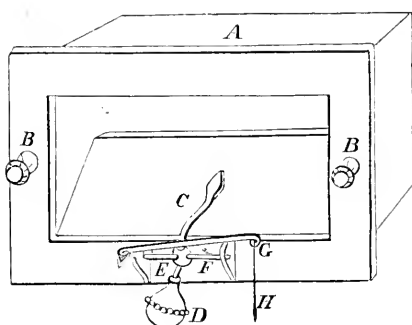
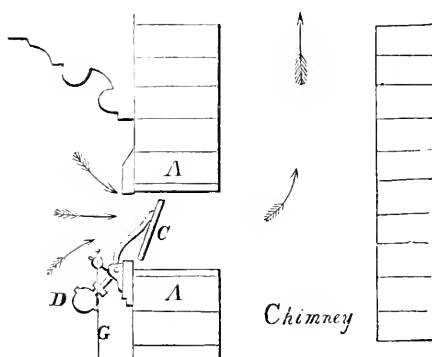


Fig. 9.



B, B, (fig. 8,) are two screws by which the front frame, carrying the valve, is fixed to A. C, is the valve, consisting of a metallic plate, turning on the axles E, F, and balanced by the weight D, so that the opening into the chimney shall be completely closed by C, when there is no draught into the chimney, and especially when there is a tendency for the air of the chimney to return into the room. The action of the valve in allowing the air of the upper part of the room to pass into the chimney is shown in fig. 9. G, is a wire, the lower end of which is fixed to the wall within reach of the hand, and by shortening or lengthening this by means of a screw, the extent to which the valve can open is regulated.

But the great difficulty in connexion with ventilation, is not so much in withdrawing the foul air as in substituting that which is pure in an unobjectionable way. If the external air be allowed to enter the apartment at only a few points, it will almost inevitably occasion cold currents that will prove sources of annoyance. Means have been tried for causing a mechanical diffusion of the cold air as it enters, but none of these have completely answered. A patent has been taken out for a ventilator to be fixed in the window, which consists of a number of slips of glass fitted into one of the squares, in the same way as louver board ventilators are constructed. The object of this is to divide the air, as it enters, into several strata, and to give to these an upward direction, so that the cold air may pass along the ceiling, and thus become to some extent warmed and diffused before its descent. But the objection still applies to this method, that the air is admitted at a few points only, and if there be much difference between the temperatures of the external air and of that within the room, there will frequently be complaints of cold currents.

It has recently occurred to me, that a druggist's shop offers admirable facilities for effecting a very complete system of ventilation in an unobjectionable and inexpensive way. In fitting the shop, it is customary to commence by wainscoting the walls, so as to facilitate the fixing of the shelves and drawers, which are screwed to the boards in the wainscot. The way in which this is done is represented in fig. 5, where it will be seen that there is a vacant space B, between the wall and the wainscot, occasioned by the battens to which the latter is fixed. Now, as this space extends to the window, it would be easy to make an opening of suitable size from this to the external air. This being effected, the air may be allowed to pass through an infinite number of small apertures in the wainscot, and thus be very widely diffused. Moreover, the air may be warmed before diffusing itself into the apartment, by means of a steam pipe carried through the space B.

Division of the Shop into Compartments.—The arrangement and fitting of the shop will, of course, depend on the kind of business for which it is designed. In this country the business of a chemist and druggist is often of a very mixed character; even in those establishments where the business is purely pharmaceutical, it will admit of being classified; and the shop is sometimes divided into compartments, each of which is fitted up expressly for a particular class of business. In these cases there are frequently separate compartments for *retail*, *wholesale*, and *dispensing* business; and there may be a fourth compartment, in which the junior apprentice or assistant is engaged in putting up articles, such as Epsom salts, soda and scidlitz powders, &c., ready for sale, with a view of facilitating the despatch of business.

If it be intended to adopt this plan of dividing the shop into compartments, it will be necessary to consider, in the distribution of the bottles and drawers, what articles would be most conveniently placed in each compartment. Thus, the syrups, pills, extracts, tinctures, powders, distilled waters, and essential oils, are, with few exceptions, required in the dispensing compartment; lozenges, articles of perfumery, most whole or unpowdered drugs, together with some of the distilled waters, tinctures, &c., should be in the retail compartment; the junior apprentice's compartment may contain those articles that are the least frequently required; while the fitting of the wholesale compartment must depend on the character of this class of business.

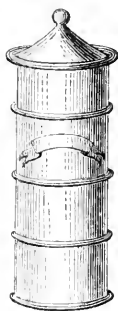
There are three kinds of receptacles, namely, *drawers*, *jars*, and *bottles*, that are required for containing the several substances which are arranged against the walls. In some old establishments a much larger number of drawers were used than is generally the case in those of the present day. The Pharmaceutist now uses, with advantage, a large number of bottles, and not so many drawers.

It will be found to conduce much to the symmetrical appearance of the shop, if the fittings be so arranged that the lines formed by the drawers, shelves, &c., shall run uniformly round the apartment. The cases of drawers, which will form the first or lowest part of the fittings, ought not to be high; about thirty-nine or forty inches will be found to be a good height from the ground to the top of the drawers. If they extend higher, it will necessarily cause a great part of the bottles to be placed so high up against the wall as to be beyond reach of the arm, without the aid of a step-ladder. This is an inconvenience that ought to be avoided as much as possible; and with this view it will be well to have a deep cornice, above the shelves (as shown in fig. 5), whenever the size of the apartment will admit of it.

[Perhaps the most eligible arrangement for a retail, or dispensing

shop is to have the shelving in pannels of three feet in width, with pilasters between. One third of these divisions should be in alcoves with shelving for bottles from quarts to four ounces in size; every alternate shelf being occupied by liquids and salt-mouthed bottles; and as convenient to the counter as possible for prescription use. The practice of having very large bottles in a retail store is objectionable except for a few liquids, as alcohol, rosewater, &c. With these and a few other exceptions, there need be no bottles for liquids larger than half gallons, or quarts. When one or two gallons of a

Fig. 10.



tincture is exposed for a long time to the action of the light it is deteriorated. These preparations may be made in common bottles and kept in the store-room, and the shop bottles replenished when required. The space near the ceiling is frequently divided off into gothic arches: whether this form or another be adopted, the space in question is advantageously occupied by japanned tin canisters of the form, fig. 10, which may be fourteen inches high, and six in diameter. There being no shoulder, allows ready access to the interior. Such vessels are very appropriate for herbs.—W. P.]

The Dispensing Counter.—The construction of the dispensing counter is deserving of special and minute consideration. The ease, accuracy, and expedition, with which the dispenser performs his work, will, in a great measure, depend upon the arrangement of this part of the fittings. It is a very inconvenient mode of proceeding to have the drawers fitted into the counter without any reference to their particular applications, and then to appropriate them as they are required; for it is much easier to plan a well-arranged counter on paper, than to make the required alterations in one that has been imperfectly constructed.

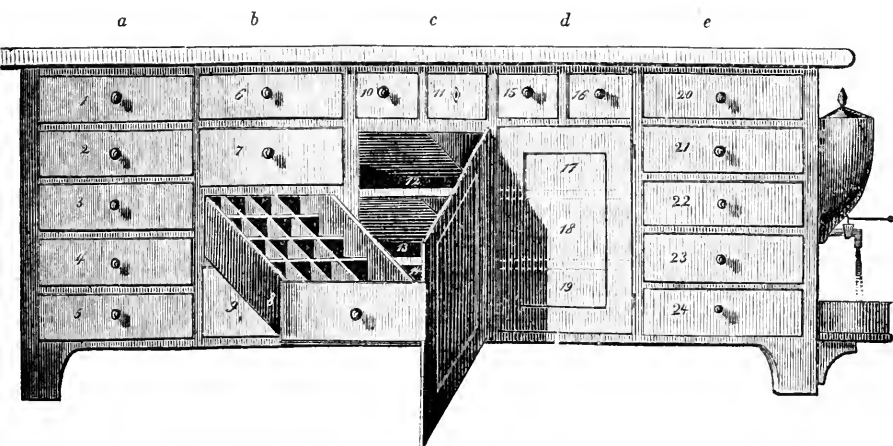
The first point to be considered is, what part of the shop shall be appropriated to this department? It is desirable that the dispensing counter should be so placed that it shall command good light, and that those engaged at it may not be exposed to unnecessary interruptions. A question may arise, as to what is the best direction for the light to fall? When this can be made a matter of choice, it will be found advantageous to have the window to the left hand of the dispenser, so that his right hand may not cast a shadow over his work.

The height of the dispensing counter is a matter of some importance; if it be too low, it will affect injuriously the health and stature of the dispenser, by causing him to stoop, and this, from constant habit, has been found to occasion a slight curvature of the spine,

which has been called the dispensers' hump. Thirty-six inches will be found to be a good height for the counter. The top should be of hard wood, and should be at least two inches in thickness.

The arrangement of the drawers, however, is the most important consideration in reference to the construction of the dispensing counter. A difference of opinion appears to exist, as to whether it is most convenient to have a great number of small drawers, or a smaller number of large ones, with internal divisions in them. I think there are several reasons for preferring the latter. The following arrangement of a dispensing counter is given as one that has been found practically convenient.

Fig. 11.



DISPENSING COUNTER.

Fig. 11, gives a view of the working side of this counter, showing the distribution of the drawers and cupboards in it. It has five divisions over which the letters *a*, *b*, *c*, *d*, *e*, are placed. The drawers, &c., are intended to be appropriated in the following manner:—

Division *a*.

1. Contains all the requisites for the preparation and dispensing of powders, such as boxes, capsules, cards, horn spoons, wrappers, spatulas, &c.

2. Paper bags of various sizes, for containing herbs, &c.

3. Pill-boxes, and wide-mouth bottles, with corks fitted to them.

4. Covered pots, for ointments, &c.

5. Empty, for any miscellaneous or forgotten articles.

Division *b*.

6. All the requisites for dispensing mixtures, draughts, &c., such as corks, caps for the bottles, labels, twine, &c. (See fig. 12.)

7, 8, and 9. Drawers with divisions within, for containing bottles, from the smallest size up to eight or ten ounces.

Division *c*.

10. Contains the price-book, directory, paper for copying prescriptions on, &c.

11. The till or cash-drawer, with lock and key.

12. Recipe book, for copying prescriptions into.

13. Bell-metal and iron mortars.

14. Three shelves, for pill machines.

Division *d*.

15. Small slips of paper.

16. Knives, plaster irons, capsules for melting plasters in, &c.

17. Graduated measure glasses, strainers, and small dishes.

18. Porcelain or wedgwood mortars, for mixtures.

19. Ditto, ditto, for powders.

Division *e*.

20. Towel, duster, scissors, knives, &c.

21. Paper, cut to different sizes.

22. Green glass bottles, from ten to sixteen or twenty ounces capacity.

23 and 24. For miscellaneous or forgotten articles.

To facilitate the opening and shutting of the drawers in the counter, and obviate the inconvenience frequently experienced from their moving difficultly and irregularly, I have had small wooden rollers (fig. 14) fixed in the frames, and can strongly recommend this addition.

I will now describe, more particularly, the internal arrangement of the drawer No. 6, containing the requisites for dispensing mixtures, &c. This is represented in fig. 12. It is $20\frac{1}{2}$ inches long, $15\frac{1}{2}$ inches wide, and four inches deep, and is divided into thirteen compartments, which are severally numbered in the drawing.

Divisions 1, 2, and 3, contain corks of different sizes, and the pincers fig. 13, for compressing and softening the corks when they are used. The insertion of the cork being the first operation to be performed after making the mixture, the front compartments are occupied with the requisites for performing it. Immediately behind these are other implements, which are subsequently required. Division 4 contains the first papers for putting over the corks; division 5, the coloured caps; and division 6, embossed and ornamented caps. Division 7 contains waxed paper, and tin-foil; for covering ointments; and 8, 9, 10, and 11, are occupied with labels of different kinds, both plain and ornamented. Lastly, 12 and 13 contain white and coloured string.

Fig. 12.

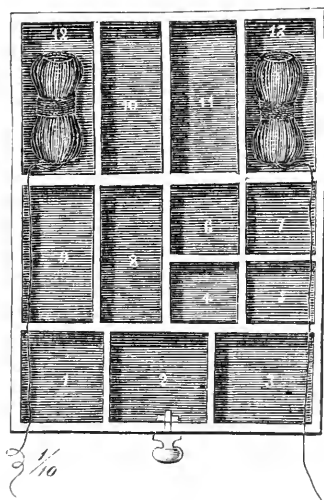


Fig. 13.



Fig. 14.



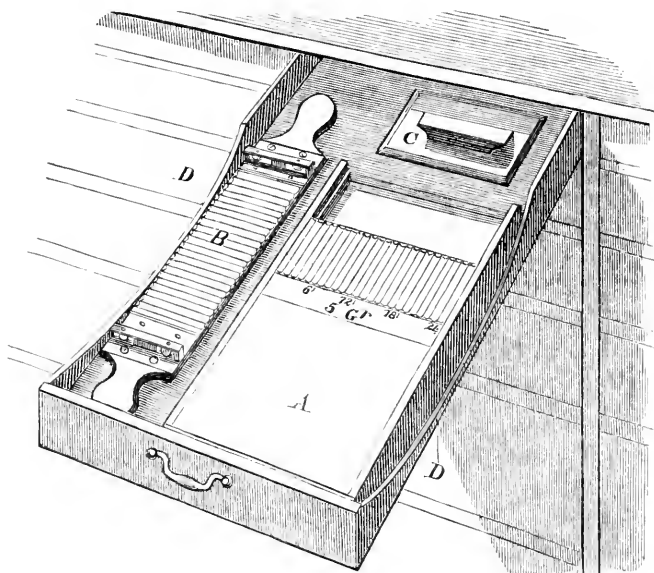
[In the arrangement of the counter, the space immediately below the top should be devoted to slides twenty inches by two feet in superficial size. They are useful for enlarging the counter room, and save the counter top from the action of corrosive liquids. The practice of labelling every package sent from the shop requires an extensive provision for cut labels. The shallow drawers for these may very properly be placed below the slides in a line. It is well to put labels for liquids and dry articles in separate drawers, and to arrange them in alphabetical order; indeed every facility should be adopted to render their use easy to the dispenser.—W. P.]

Some difficulty is frequently experienced in determining the best place for keeping and using the pill-machines. Where there is much dispensing business done, the pill-machine is in almost constant use, so that, having to take it out of a cupboard, when required, and return it again, with its several parts, when done with, would be troublesome, and would occupy time unnecessarily. Moreover, under such an arrangement, a place would be required, on the counter, for using the machine, which, in many instances, could not be conveniently spared, and the powder employed for rolling out the pills, would occasion dust, which, together with the machine itself, would interfere with the neatness and cleanliness which ought to characterize the dispensing counter.

Some years ago, my attention was directed to this subject, and I adopted the arrangement which is represented in fig. 15. The pill-

machine A, is fixed in a shallow drawer, immediately under the top of the counter, a place being left on one side for the cutter B, to lie in when not in use, and another place at the back for the roller C.

Fig. 15.



PILL-MACHINE.

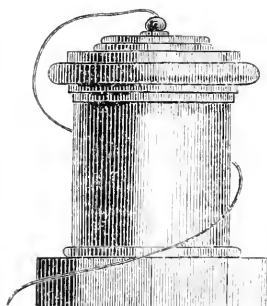
The two sides of the drawer, at D, D, are cut down, as shown in the drawing, to make room for the lateral guides of the cutter. There is, also, a stop fixed in the top rail of the frame in which the drawer runs, so that, when pulled out, as shown in the drawing, the front of the drawer, from its weight, falling a little below the horizontal plane, and the back edge coming in contact with the stop, a check is put to the return of the drawer when pushed. The operator, therefore, leans against it, and thus keeps it fixed while he cuts the pills with the cutter, and as soon as the process is completed, on slightly elevating the front of the drawer, so that the back edge shall clear the stop, it is pushed in, and the whole apparatus removed from sight.

This arrangement has been adopted in one of the largest dispensing establishments in London, and has been found practically convenient.

The ointment-slab might be disposed of in a similar way.

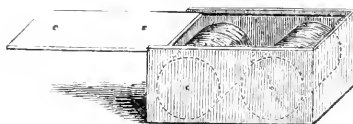
The string-box, fig. 16, and cork-squeezer, fig. 18, are frequently employed by English Pharmacutists, instead of those delineated in figs. 12 and 13.

Fig. 16.



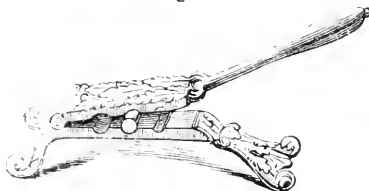
STRING-BOX.

Fig. 17.



TWINE-BOX.

Fig. 18.

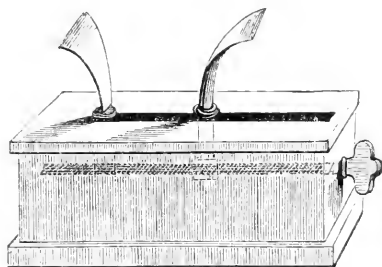


CORK-SQUEEZER.

[Fig. 17 represents a twine-box with two spool-wheels, on which the twine is wound, and the ends slipped through the holes in the lid. This form possesses several advantages.—As the mortar for contusion is constantly required in dispensing, a mortar-stand should be placed in proximity to the end of the counter. If possible, it should be a massive piece of wood, and extend through the cellar into the earth, to give it solidity. The jarring caused by the process of contusion, when the mortar-stand rests on the floor, soon destroys the accuracy of a delicate balance.—W. P.]

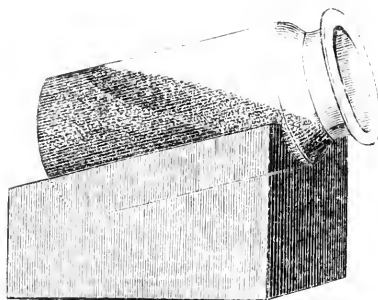
The powder-folder is a necessary appendage to the fittings of the dispensing counter. There are several forms of this implement, of which fig. 19 is one of the most approved.

Fig. 19.



POWDER-FOLDER.

Fig. 20.



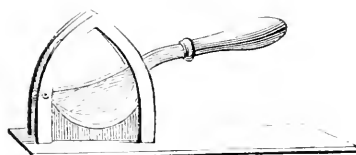
BOTTLE-STOOP.

The bottle-stoop, fig. 20, is used for giving the proper inclination to a bottle containing any powder, so as to admit of some of the contents being taken out on the point of a knife, for use in dispensing.

It consists of a block of wood, of the form shown in the drawing, with a groove in the upper surface, for the reception of a bottle in an oblique position.

The sink with supply of water, for washing measures, &c., should be conveniently situated for the use of those engaged at the dispensing counter.

Fig. 21.



ROOT-CUTTING KNIFE.

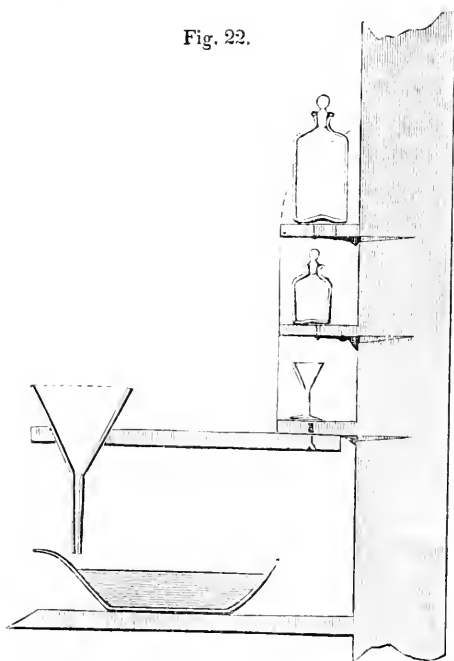
The root-cutting knife, fig. 21, will be found useful, especially at the retail counter.

A good clock must be mentioned, among the fittings, indispensable to the shop. If possible, it should be so fixed, that it can be seen by those

engaged in the business, as well as by the customers.

THE LABORATORY.—In most cases, the situation of the laboratory will not be altogether a matter of choice, as there is, generally, only one part of the premises that can with any propriety be appropriated to this purpose. It ought always to be on the ground floor, as the weight of the requisite furnaces, presses, and other apparatus, and the large quantities of water used in many of the processes, and for

Fig. 22.



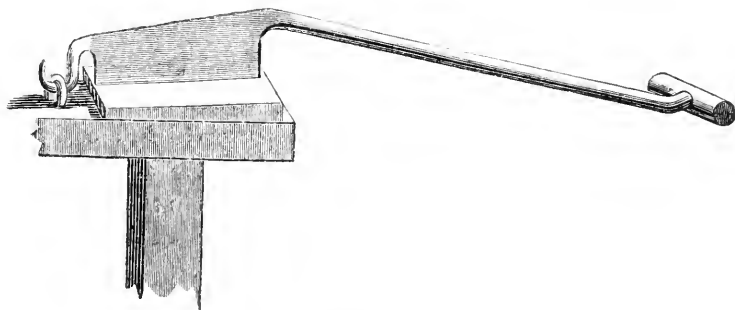
washing and cleaning, would soon destroy the rafters and ceiling below them, of any room below this floor. It should be well lighted, ventilated, and drained, and, above all things, it should have a plentiful supply of water.

The essential fittings of the laboratory are,—the furnaces, stills, steam apparatus, refrigerators, and presses, which will be hereafter described; a capacious sink, with water laid on, and perforated shelves fixed over it, for draining bottles; a fixed side table, for performing the smaller operations upon, and above this, a set

of tests, test glasses, funnels, glass measures, and a perforated shelf,

for supporting funnels, as shown in the drawing (fig. 22); a strong movable table, which may be placed in any part of the laboratory; a druggist's root-cutting or slicing knife (fig. 23); a large marble mortar, and an iron or bell-metal mortar. There should also be a desk, on which to keep the journal of the operations of the laboratory, and, above it, a glass-case, containing the Pharmacopœias and a few

Fig. 23.



ROOT-CUTTING KNIFE.

other books. These, together with some movable apparatus, which will vary according to circumstances, will form the principal features in the laboratory. In some cases, however, the drying closet may be fixed here.

STORE-ROOM.—In the store-room, the stock of the greater part of the drugs is kept, to be supplied from time to time, as wanted, to the shop and laboratory. It should be a dry and easily accessible room. The stock of roots, woods, barks, seeds, fruits, resins, gums, extracts, powders, salts, and mineral productions, are, with few exceptions, to be kept here. Many of these substances may be conveniently pre-

Fig. 24.

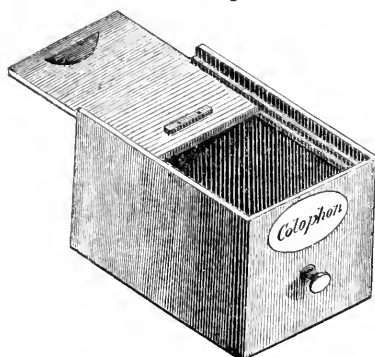
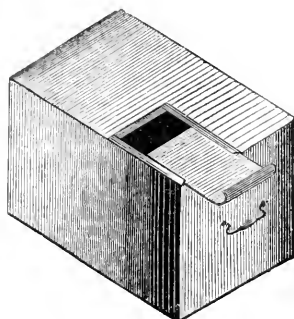


Fig. 25.



served in wooden boxes, such as that represented in fig. 24; or in tin boxes, such as fig. 25; which may be placed on shelves round the

room. The fittings and arrangement of the store-room must, however, depend very much upon the character of the business to which it is attached.

With the view of facilitating the finding of the different articles kept in the store-room, there ought to be a catalogue in which they are all entered, with references to letters and numbers, indicating in what part of the room they may be found. This catalogue should be hung against the wall, near to the door, so that reference might be made to it on entering.

STORE-CELLAR.—It is desirable to have a good underground room or cellar for keeping the store of those substances which are injured by variations of temperature, or are best preserved in a cold place. The syrups, ethers, distilled waters, and some of the acids, belong to this class of substances. The oils and fats, including ointments; in fact, most liquids, especially volatile liquids, and some solids, such as efflorescent salts, may with propriety be kept here.

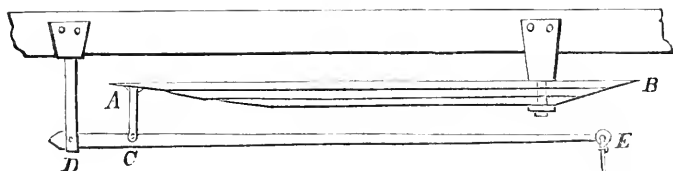
The same conditions which render a cellar suitable for the preservation of wines, will constitute the essential requisites in a good store-cellar. It should be as dry as possible, free from vibrations to which other parts of the house are often subject, and as airy as is compatible with the maintenance of a uniform temperature. There should also be a catalogue of the articles kept here.

DRYING-ROOM OR LOFT.—In Germany every druggist dries the indigenous herbs, flowers, roots, &c., which he keeps in stock. In this country this practice is not general, at least in large towns, where there are herbalists from whom, or from the wholesale druggists, such substances are usually obtained ready for use. It is, however, desirable in all cases to have a good *drying-room*, in which the Pharmacist may conduct any processes of spontaneous desiccation. A loft at the top of the house (the space immediately under the roof) is generally appropriated for this purpose: it has the advantage of being exposed to the influence of the sun and wind, while at the same time dust and vapours, which gain access to other parts of the house, may be excluded. Sufficient air will frequently be admitted between the slates of the roof, or, should this not be the case, provision must be made by a kind of louver boarding that will admit air but not wet. If it should be found inconvenient to use the loft in this way, a room in another part of the house may be selected to answer the same purpose; in which case it will be desirable that it should have two windows having different aspects, so that there may be a current of air through the room.

POWDERING-ROOM.—In this apartment the processes for the reduc-

tion of drugs to powder are conducted. It should be on the ground floor, so that the mortars may have a solid foundation; and, above all, it should be a perfectly dry room, to which steam and damp have no access. It is desirable that the drying-closet should be contiguous

Fig. 26.

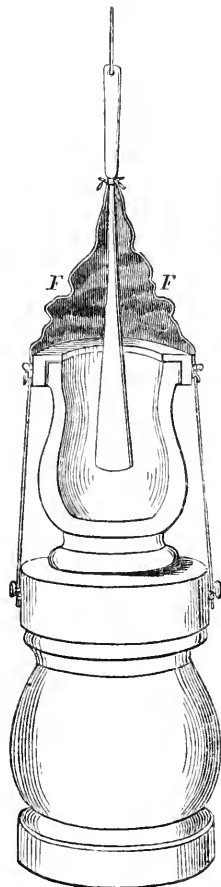


to, or at least easy of access from, this room, as it is often necessary in powdering drugs that they, as well as the sieves, should be put into the closet several times during the process.

The only fittings required in the powdering-room are, the mortars with spring pestles; the sieves, which should be kept in drawers or boxes; and a strong table on which to use the sieves. There may also be added to the fittings of this room, if the space will admit, a porphyry slab and muller, and the root-cutting knife (fig. 23), which would otherwise be in the laboratory.

It will be well to have one mortar of iron and one of bell-metal, as there are some cases in which the former, and others in which the latter metal, will least contaminate the substances to be pounded in them. The pestles should be attached to springs, so as to lessen the labour of pounding. The kind of spring represented in fig. 26 will be found to answer very well, and to possess some advantages over the long wooden spring frequently used.

It consists of a carriage-spring, A, B, one end of which is fixed to a beam in the ceiling, while the other end is connected by a rod A, C, with the bar D, E, from which the pestle is suspended, as shown in the drawing. F, F, is a leather cover, by which the contents of the mortar are confined during the process of powdering.



MORTAR AND SPRING PESTLE.

CHAPTER II.

ON WEIGHING AND MEASURING, AND THE DETERMINATION OF SPECIFIC GRAVITIES.

AMONG the operations performed in the preparation of medicines, there are none which are of more frequent occurrence, or which require greater care and precision in performing them than the operations of weighing and measuring. In selling medicines, in dispensing medicines, and in preparing or manufacturing the different medicinal compounds, there are constant occasions for the use of the *balance* and the *measure*. These instruments are intended for the accurate adjustment of the quantities of the substances employed in our operations; but the full accomplishment of the object contemplated will depend in a great degree upon the proper construction of the instruments, the care with which they are preserved, and the manual dexterity with which they are used.

The weight of a body is the measure of its gravitating force, and this is in direct proportion to its mass, or the quantity of matter which it contains. This force is expressed with relation to some known standard of resistance, which is just sufficient to prevent the body from falling to the ground. The standards thus used, however, are perfectly arbitrary, and they frequently differ in different countries, which is a great evil.

In the first instance, some natural products, such as seeds, which were easily attainable, and the weight of which was pretty uniform, were used as units, from which other denominations of weight were calculated. Thus, by a law passed in the year 1266, it was enacted, "That an English penny, called a sterling, round and without clipping, shall weigh thirty-two *wheat corns*, from the midst of the ear, and twenty pence shall make an ounce, and twelve ounces one pound."*

Not only have different countries adopted different standards of weight, but even in the same country, as in this and others, two or

[* The reader is referred to a paper by Dr. B. Ellis on weights and measures. *Amer. Jour. Pharm.*, vol. ii., pp. 111 and 188.]

more different standards have been recognised and used at the same time. The inconveniences resulting from this practice have long been felt, and the attention of scientific men has, for many years, been directed to the subject, with the view of fixing upon one standard which could at any time be tested by comparison with some phenomenon of constant and unvarying occurrence. Such a standard, it is hoped, will ultimately be adopted by all civilized countries, to the exclusion of every other.

In this country an attempt has been made to introduce a greater degree of uniformity and certainty than originally existed with reference to our weights and measures.

The imperial standard weight, or troy pound of 5760 grains, from which all our other weights are now calculated, is determined, in case of any doubt, by comparison with a given measure of distilled water, weighed at a temperature of 62° Fahr., the barometer standing at thirty inches. Thus, a cubic inch of distilled water weighed in air with brass weights, at the temperature above stated, "is equal to two hundred and fifty-two grains and four hundred and fifty-eight thousandth parts of a grain, of which, as aforesaid, the imperial standard troy pound contains 5760."

The measure from which the weight is estimated, is determined by means of a pendulum vibrating seconds of time, in a vacuum, at the latitude of London, and at the level of the sea. It has been found that the length of such a pendulum, in comparison with our yard of thirty-six inches, would be thirty-nine inches and one thousand three hundred and ninety-three ten thousandth parts of an inch (39.1393 inches). This, then, is the foundation of our standard both of weights and measures; and if, from any circumstance, all the weights and measures in the country, including those which are kept for comparison in the custody of the Clerk of the House of Commons, should be destroyed, we have the means of renewing them with the absolute certainty of their being the same.

But all that our legislature has done, has been to fix and afford the means of perpetuating certain standards of weight and measure which were previously in use among us, excepting in regard to some slight alterations which were, at the same time, made in some of the minor divisions.

In France, in the days of the memorable revolution of 1792, when all regard for ancient customs and institutions was openly repudiated, a much more sweeping and radical change was made, and a system established, which is admitted by all scientific men to be the most

complete, philosophic, and generally convenient, that the wit of man has yet suggested. The French philosophers were not satisfied with attempting to reconcile old standards with new and scientific principles;—they did not merely propose to frame a system of weights and measures for the use of the French people; but their ambition fostered the belief that they were framing systems for the whole world, and in this particular instance it is not improbable that their anticipations may be realized. Already French weights and measures are adopted by scientific men throughout a great part of Europe; and even in England, where they have not yet been generally adopted, the feeling is daily becoming stronger in their favour.

In the French system, as in ours, the unit from which all the other calculations are made, is a measure of extension. They did not, however, take the pendulum for estimating their unit, but the measurement of the meridian of the earth. Thus, the ten millionth part of a quarter of the earth's meridian, is the unit from which their calculations are made. This unit, or first measure, is called the *metre* (from the Greek word *μετρον*, measure). It is thirty-nine inches and three hundred and seventy-one thousandth parts of an inch of our measure (39·371 inches). The metre is divided into ten parts, each of which is called a *decimetre*; and this is again divided into ten parts, each of which is called a *centimetre*.

A cubic decimetre is called a *litre*, and this is taken as the unit of measures of capacity.

A cubic centimetre of distilled water, at its maximum density, that is at a temperature of 39·5° Fahr., is taken as the unit of weights, and is called a *gramme*. All the subdivisions and multiples of these units, are by tens, and the system is, therefore called the *decimal system*.

The importance of having a good and uniform system of weights and measures, cannot be too highly estimated in a scientific point of view.

Weights, as already stated, are used for estimating the resistance required to overcome the gravitating forces of bodies. In applying them, an instrument is employed, which is called the *balance*. This instrument is a lever, supported at its centre of gravity, in such a way as to afford to it the greatest practicable freedom of motion. Different forms and degrees of sensibility are given to the balance, so as to adapt it for the different circumstances under which it is applied. The lever, or beam, is generally supported on knife-edges, and, according to the sharpness of these, and the hardness of the planes on

which they rest, will be the delicacy of the indications. In some cases several grains are required to give the preponderance to one end of the lever over the other, while the most delicate balances will turn with the five hundredth or one thousandth part of a grain. Inflexibility in the lever, and perfect equality in the length of its arms, are the most important points in reference to the truthfulness of a balance as usually constructed. The slightest variation in these respects would entirely vitiate the result of a weighing.

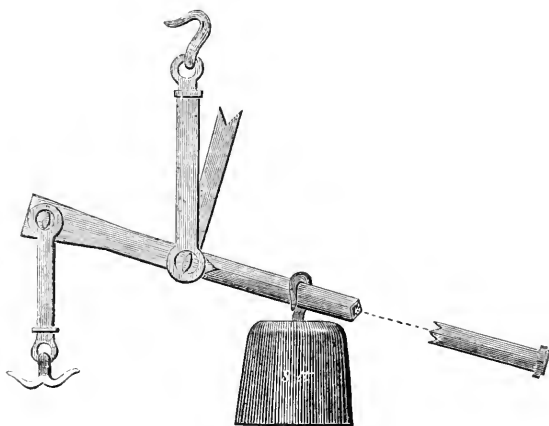
But, however accurate may be the weights, and however delicate and well constructed the balance may be, the indications afforded are not, in the majority of cases, the true weights of the bodies weighed. The means usually adopted for determining the weight of a body are, in one respect, defective. We weigh bodies in a gravitating medium, and therefore do not determine their absolute gravitating force. Every one is familiar with the fact, that if a solid body be put into water, the force required to prevent it from sinking is less than that which would be required for supporting it in the air. In fact, when a body is immersed in water there is a force equivalent to the weight of the volume of water displaced by the body, which presses it upwards, and thus counteracts its gravitating force. The weight of a body in water, therefore, is less than its true weight; so also is the weight of a body in air. Air is a gravitating fluid like water, although its weight is very much less; and the weight of a body weighed in air is either more or less than its true weight to the extent of the weight of a volume of air equal to the difference between the volume of the weighed substance and that of the weights used. This source of error is never practically taken into account.

There are, however, some sources of error in weighing and measuring which it is important to guard against. He who properly estimates the importance of accuracy in weighing and measuring medicines will satisfy himself that his balances and measures are true and his weights correct. Nor is accuracy in these respects the only necessary consideration. It is equally important to make a selection of instruments suitable for the purposes to which they are to be applied. In a pharmaceutical establishment several balances of different degrees of delicacy are required. When heavy weights are employed, the lever and other parts of the balance must be proportionately strong, and in these cases the knife edges are generally less sharp, and the indications consequently less delicate than are those of the balances used for weighing smaller quantities. It is customary in the retail department of the shop to have at least two kinds of balances,—one

for weighing quantities varying from a quarter of an ounce up to a pound or two pounds, and the other for larger quantities. The former of these balances should be sensibly affected by the preponderance of a grain or two in either pan; the latter will not generally be sensible to less than twenty or thirty grains.

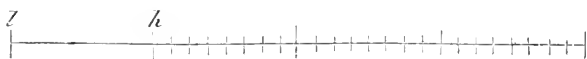
In the warehouse, balances of a still larger and stronger description are required, the indications afforded by which are even less accurate than the above. For approximative indications the steelyard may be sometimes conveniently used, as the weighing is effected with a single weight. Fig. 27 is a representation of this instrument. It consists of a lever, the two arms of which are of unequal length. The weight used is suspended from the long arm of the lever in such a manner that it may be moved to any part of it, and according to its position will the weight of the substance attached to the other short end of the lever be estimated. Thus, supposing h , fig. 28, to be the point of suspension of the lever, and l the end of the short arm to which the substance to be weighed is fixed, a weight placed on the long arm

Fig. 27.



would change its value according to its position, at the several divisions. If the weight were eight pounds, it would have that value when

Fig. 28.

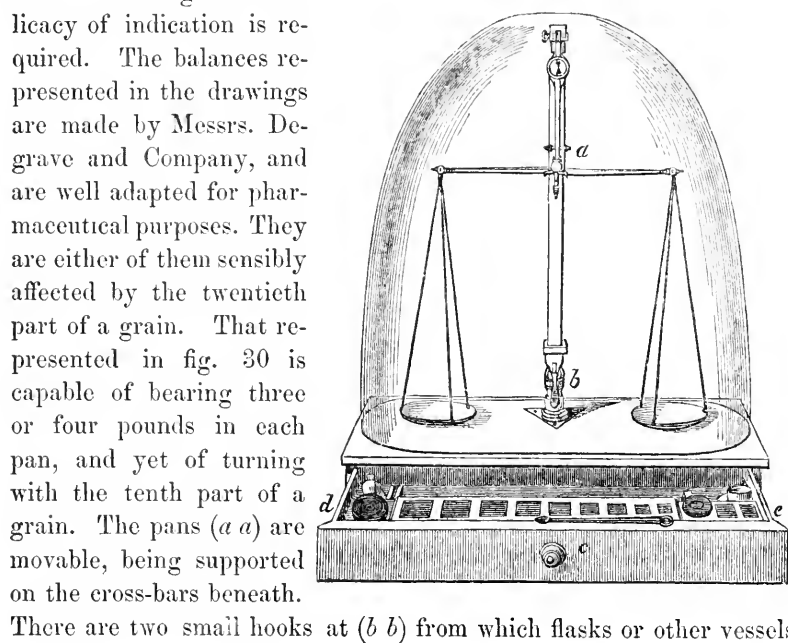


placed at the eighth division from h , and would change its value if moved either nearer to or farther from the point of suspension of the

lever, having the value of one pound at the first division, and of twenty-four pounds at the last division. In like manner a weight of eight ounces would give similar indications of smaller amount. [In this country a variety of platform scales of all capacities has, in a great degree, superseded the simple scale-beam on the steelyard principle, from their superior convenience of use.—W. P.]

Other balances, again, are required for the purposes of dispensing. There are two kinds of dispensing balances commonly used,—one is suspended from a fixed pillar, as represented in fig. 29,—the other is suspended, when used, from the hand of the operator (see fig. 34), and is kept in a box containing the weights when not in use. The dispensing balance should be sensible to variations of a tenth part of a grain, or even less. The standard balance is not so convenient for dispensing as that which is supported in the hand, the process of weighing being conducted much more expeditiously with the latter than with the former; the hand-balance is therefore used in all establishments where there is much dispensing business. But should the standard balance not be used in dispensing, it would nevertheless be desirable that the pharmacist should have a balance such as fig. 29, or such as fig. 30, for occasional use in taking specific gravities, and for other purposes in

Fig. 29.



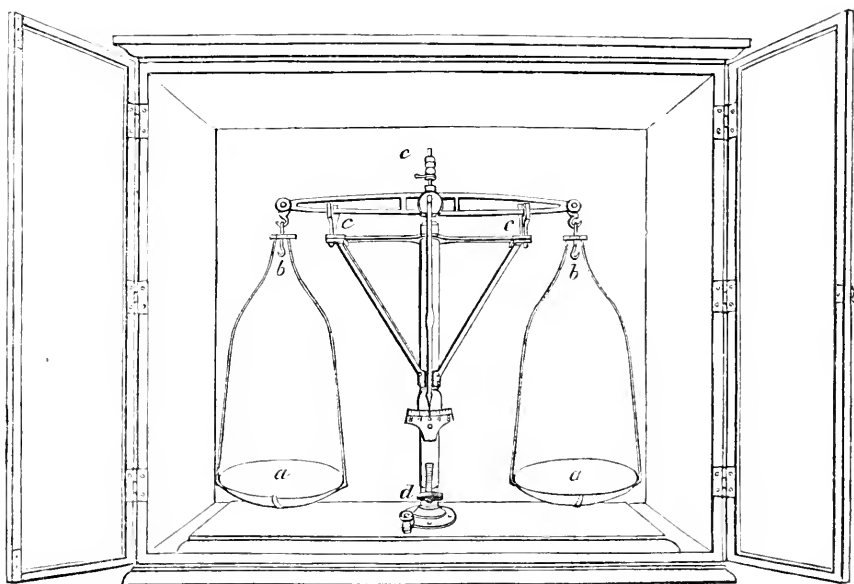
which some degree of delicacy of indication is required. The balances represented in the drawings are made by Messrs. Degrave and Company, and are well adapted for pharmaceutical purposes. They are either of them sensibly affected by the twentieth part of a grain. That represented in fig. 30 is capable of bearing three or four pounds in each pan, and yet of turning with the tenth part of a grain. The pans (*a a*) are movable, being supported on the cross-bars beneath. There are two small hooks at (*b b*) from which flasks or other vessels

which would not stand on the pans may be suspended. The pans of this balance, when at rest, are not in contact with the slab to which the pillar is fixed, and the beam is prevented from oscillating by the supports (*c c*), which are pressed down by means of the lever (*d*) when the weighing is performed. There is a small movable bar (*e*) which turns in a horizontal plane on a vertical pin fixed over the centre of the beam. The object of this is to afford an easy method of adjusting the equilibrium of the pans if they should not exactly balance, by turning the projecting end of the little bar towards the lightest end of the beam, and thus throwing additional weight on that side.

Still more delicate balances are required for analytical purposes.

There are two kinds of weights required to be used by the pharmacist. The weights indicated in prescriptions, and those expressed in the formulæ of the pharmacopœias, appertain to apothecaries' weight, while those by which merchandise, including medicines, are bought and sold, appertain to avoirdupois weight. Sets of weights of each of these denominations must therefore be kept. It is not customary for pharmacutists to keep more than a set or two of apothecaries' weights, and those extending only up to a pound. One such set there certainly ought to be for use when required. Of avoirdupois weights much more comprehensive sets are required, as even in preparing

Fig. 30.



medicines, the substances are weighed with these weights when the quantities are large. I have given a comprehensive table of the equivalents of troy and avoirdupois weights, in the *Supplement to the Pharmacopœia*, which will be found useful in facilitating the necessary calculations when the one denomination of weight is substituted for the other in any formulæ. [See page 51.]

[Very excellent balances are made in this city, by Mr. Duffey, for the use of the apothecary. They are preferred with a standard column, and when new turn with $\frac{1}{30}$ th of a grain. The pans are movable, and a small ball weight revolving on the lower index serves to regulate the centre of gravity of the beam.

The balance-case represented at fig. 31, is recommended for its great convenience. One third of the sides, top, and the front, are movable on the hinges (*b b*), and when turned up so as to rest on top of the fixed part, the balance can be approached from the sides as well as front, a point very desirable to the operator. It is instantly closed by bringing down the front, the weight of which always keeps it closed.

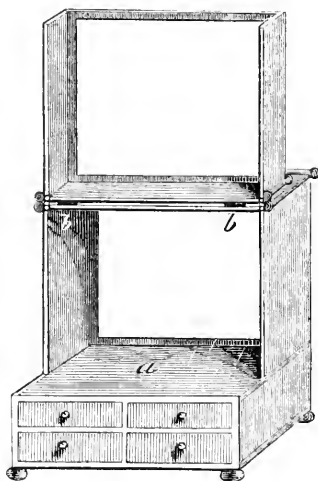
One of the drawers is devoted to weights; the grain weights being kept in a separate division, so as not to be injured by attrition with the larger. Another should contain papers for enclosing powders, and a small spatula. A third may contain fancy paper for capping vials, and the fourth several watch-glasses, small wide-mouthed vials, pieces of tin-foil, &c., to facilitate the weighing of iodine, extracts, volatile oils, &c.

The balance-case should be placed in a situation where it will not be subject to jarring, which is a fruitful source of injury to the knife edges of a delicate balance.—W. P.]

The measures used for pharmaceutical purposes when intended for measuring quantities not exceeding a pint, are made of glass; and these are graduated so that the same instrument will indicate several different quantities.

Very small quantities of liquids are sometimes measured by dropping them from the lip of the bottle, the stopper being slightly raised from its place, so as to allow the liquid to pass; but this method is subject

Fig. 31.



to much inaccuracy, as not only do the drops of different liquids vary considerably in size, but so also do those of the same liquid when dropped under different circumstances. Mr. Alsop, several years ago, published the result of some experiments which he made with the view of showing the extremes of variation to which this mode of measuring was liable.

Fig. 32.



The variations, depending not only on the degree of tenacity of the fluid, but also on the extent of moist surface to which the suspended drop is attached before it falls, were found to be influenced by the size of the bottle, and the angle of inclination at which it is held during the operation of dropping. The following are some of Mr. Alsop's results, showing the number of drops required to measure a fluid-drachm, when dropped from a large or a small bottle :

	Dropped from a large bottle.	Dropped from a small bottle.
f5j. Diluted sulphuric acid . . .	24 drops.	84 drops.
" Scheele's hydrocyanic acid . . .	35 "	70 "
" Distilled water . . .	31 "	54 "
" Solution of ammonia . . .	40 "	48 "
" Tincture of opium . . .	84 "	135 "
" Rectified spirit . . .	100 "	130 "
" Tincture of muriate of iron . . .	100 "	150 "

It is obvious, therefore, that medicines ought not to be measured by drops ; and there is some difficulty in apportioning minute quantities of powerful liquid medicines by the use of the common minim-measure. *Mr. Alsop's minim-meter*, fig. 32, was introduced with the view of obviating this difficulty, and it has been found from practical experience completely to answer the intended purpose. The minim-metre acts upon the principle of a syringe. In using it, it is necessary to keep the packing of the piston moistened with a little water. This being done, the piston is raised about half an inch : the point of the syringe is then dipped into the liquid to be measured, and the required quantity, or a little more, is drawn into the tube by further elevating the piston ; any excess, beyond the quantity required, is forced out by carefully depressing the piston, and the measured quantity thus adjusted, is transferred to the bottle, or other vessel, by forcing the piston completely down. After a little practice this may be done in less time than would be occupied in the operation of dropping. A stratum of air intervenes between the piston and the

surface of the liquid, as will be seen in the figure, which is represented as containing eight minims.

The best method of cleaning the measure after using it, is to draw a little water into it, then to stop the opening at the point by placing the finger over it, and to force down and again raise the piston, thus forcing the water through the packing and effectually cleansing it.

Measures of a greater capacity than a pint are generally made of tinned copper.

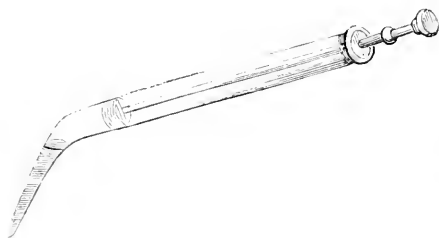
Every pharmacist ought to test the accuracy of his weights, measures, and balances.

Balances, although apparently correct, when unloaded, the two pans being in equilibrium, may, nevertheless, give incorrect indications when loaded, in consequence of one arm of the lever being longer than the other. The best test for this defect is carefully to weigh some substance, bringing the scales to a perfect equilibrium, and then to transpose the weights and the substance weighed, and observe whether this alters the result. If the balance be correct the result will be unaltered. There is an easy method of guarding against errors arising from defect in the construction of the balance, which is, to adopt what is called *double weighing*. This consists in putting the substance to be weighed into one of the pans of the balance, and any suitable substance, such as sand, into the other pan, so as exactly to counterpoise it; then, having removed the former, weights are substituted for it until the equilibrium is restored, and these weights will correctly represent the substance weighed. This method of weighing will afford correct results with any balance that is capable of turning with sufficient delicacy.

The graduation of measures is frequently incorrect, and ought therefore to be verified before the measures are used. Sometimes there is found to be a difference of half an ounce or an ounce in the capacities of two pint measures, in which case one, if not both, must be wrong. The correctness of the graduation of a measure is easily tested. In performing this operation, it is desirable to have a perfectly level place on which to put the measure. A particular part of the counter, or any other fixed horizontal board, which has been ascertained, by means of a spirit level, to be perfectly horizontal, should be selected; and this spot might always be used as a standing-place for measures in testing their accuracy. The measure is intended to indicate the volume of a certain weight of distilled water at a temperature of 62° Fahr.; and the verification is therefore effected by introducing as many ounces, avoirdupois weight, of distilled water,

at the above temperature, as the measure indicates in fluid ounces. Thus, the imperial pint contains twenty ounces, avoirdupois, of dis-

Fig. 33.



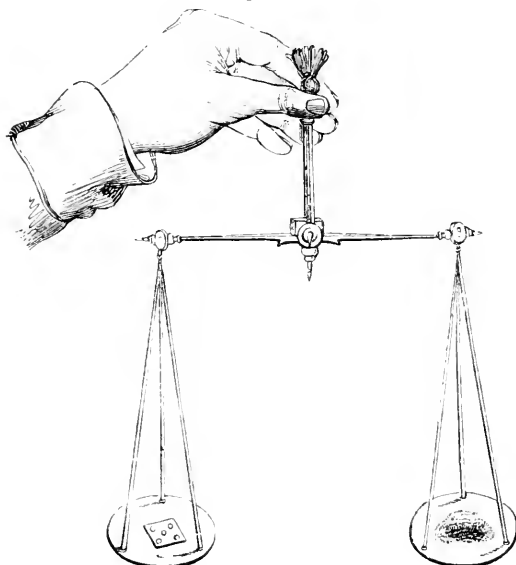
GLASS SYRINGE.

tilled water, by weight. Of course it is necessary to use accurate weights and a good balance for this operation. The balance, fig. 30, is suitable for the purpose. A glass syringe, such as fig. 33, will be found convenient for adjusting the exact quantity of water required. The water may be introduced into,

or removed from the measure with great precision by means of this syringe, without wetting the sides of the vessel.

Weights, from constant wear and occasional exposure to acid vapours, sometimes become incorrect; indeed, it often happens that the drachm and grain weights used for dispensing are incorrect when sold by the manufacturers. These small weights are not examined by the official inspectors, and they appear to be frequently made in a very careless and imperfect manner; they ought, therefore, to be tested, from time to time, by a set of well-authenticated weights carefully kept for that purpose.

Fig. 34.



METHOD OF HOLDING THE BALANCE.

In preserving the accuracy of weights, measures, and balances, it is necessary to avoid exposing them to rough treatment.

Delicate balances require to be treated delicately. They must not be handled roughly, nor should they be neglected. They require constant and delicate attention. Those that are only occasionally used should be protected from damp air

and acid fumes, by enclosing them in glass cases, or covering them with glass shades, as shown in figs. 29 and 30.

Weights ought never to be exposed to rough treatment, such as using a weight as a substitute for a hammer.

Glass measures are not liable to be rendered inaccurate by causes such as those above indicated, but copper and other metallic measures are; and it not unfrequently happens that these receive serious injury from blows, for any indentation, thus caused, on the surface of a measure, must alter its capacity.

Fig. 35.



METHOD OF HOLDING THE MEASURE-GLASS.

Finally, some attention should be paid to the manipulations of weighing and measuring. The accuracy of the indications afforded by the use of the balance and the measure will depend, in some degree, upon the manner in which the operator handles the instruments.

In performing the process of weighing, there is a certain amount

of manual dexterity required, which practice alone can impart. The proper suspension of the dispensing scales from the hand; the preservation of the equilibrium of the beam by resting the pans on a solid surface while the substance to be weighed is being introduced; and the steady, not too lofty, nor too hasty, elevation of the hand, in trying the equilibrium of the loaded pans, contribute not only to the accuracy of the result of the process, but also to the ease and elegance with which it is effected. (See fig. 34.)

Again, in measuring, it is necessary to acquire a proper and easy method of holding the measure-glass. It should be held in such a manner that the stopper of the bottle from which any liquid is about to be poured into it, may be removed by the same hand; and that, subsequently, the measure can be raised, so that the surface of the liquid shall be level with the eye of the operator, while the measure itself is kept perfectly upright. (See fig. 35.)

The practised operator, if he be really alive to the importance of strict accuracy in the results of his operations, will acquire dexterity and elegance in the methods of conducting these processes, which result from the best adaptation of every movement for the attainment of the object contemplated.

[TABLES OF AVOIRDUPOIS OR IMPERIAL, TROY, AND APOTHECARIES' WEIGHTS.

AVOIRDUPOIS, OR IMPERIAL WEIGHT.

						Equivalents in Troy grains.
1 drachm	-	-	-	-	-	27·34375
16 =	1 ounce	-	-	-	-	437·5
256 =	16 =	1 pound	-	-	-	7000·
3584 =	224 =	14 =	1 stone	-	-	98000·
28672 =	1792 =	112 =	8 =	1 hundred weight	-	784000·
473440 =	35840 =	2240 =	160 =	20 =	1 ton	15680000·

TROY WEIGHT.

1 grain	
24 =	1 pennyweight.
480 =	20 = 1 ounce.
5760 =	240 = 12 = 1 pound.

APOTHECARIES' WEIGHT.

1 grain.—gr.

20 = 1 scruple.—ʒ.

60 = 3 = 1 drachm.—ʒ.

480 = 24 = 8 = 1 ounce.—ʒ.

5760 = 288 = 96 = 12 = 1 pound.—℔.

The apothecaries' weight is that alone, the use of which is recognised by the colleges of physicians, in the preparation or dispensing of medicines, either according to the Pharmacopœia, or extemporaneous prescriptions. It is not, however, customary for pharmaceutical chemists to keep any large weights of this description, and, therefore, in preparing medicines on the large scale, it is necessary to calculate the equivalents of the weights ordered in avoirdupois weight, the latter being the only kind of large weights generally used. The following table has been prepared for the purpose of facilitating such calculations.

EQUIVALENTS IN TROY AND AVOIRDUPOIS WEIGHT.

Troy Grains.	TROY.				A VOIRDUPOIS.		
	lbs.	oz.	drs.	grs.	lbs.	oz.	grs.
60			1				60
120			2				120
240			4				240
437·5			7	17·5		1	
480		1				1	42·5
875		1	6	35		2	
960		2				2	85
1312·5		2	5	52·5		3	
1440·		3				3	127·5
1750·		3	5	10		4	
1920·		4				4	170
2187·5		4	4	27·5		5	
2400		5				5	212·5
2625·0		5	3	45·		6	
2880·		6				6	255
3062·5		6	3	2·5		7	
3360		7				7	297·5

Troy Grains.	TROY.				AVOIRDUPOIS.		
	lbs.	oz.	drs.	grs.	lbs.	oz.	grs.
3500		7	2	20		8	
3840		8				8	340
3937.5		8	1	37.5		9	
4320		9				9	382.5
4375		9	0	55		10	
4800		10				10	425
4812.5		10		12.5		11	
5250		10	7	30		12	
5280		11				12	30
5687.5		11	6	47.5		13	
5760	1	12				13	72.5
6125	1	0	6	5		14	
6562.5	1	1	5	22.5		15	
7000	1	2	4	40	1	15	
7680	1	4			1	1	242.5
9600	1	8			1	5	422.5
10500	1	9	7		1	8	
11520	2				1	10	145
14000	2	5	1	20	2		
17280	3				2	7	217.5
21000	3	7	6	0	3		
23040	4				3	4	290
28000	4	10	2	40	4		
28800	5				4	1	362.5
34560	6				4	14	435
35000	6	0	7	20	5		
40320	7				5	12	70
42000	7	3	4	0	6		
46080	8				6	9	142.5
49000	8	6	0	40	7		
51840	9				7	6	215
56000	9	8	5	20	8		
57600	10				8	3	287.5
63000	10	11	2	0	9		
63360	11				9	0	360
69120	12				9	13	432.5
70000	12	1	6	40	10		
74880	13				10	11	67.5
77000	13	4	3	20	11		
80640	14				11	8	140
84000	14	7	0	0	12		
86400	15				12	5	212.5
91000	15	9	4	40	13		
92160	16				13	2	285
97920	17				13	15	357.5
98000	17	0	1	20	14		
103680	18				14	12	430
105000	18	2	6	0	15		
109440	19				15	10	65

Troy Grains.	TROY.				A VOIR DU POIS.		
	lbs.	oz.	drs.	grs.	lbs.	oz.	grs.
112000	19	5	2	40	16		
115200	20				16	7	137·5
119000	20	7	7	20	17		
120960	21				17	4	210
126000	21	10	4	0	18		
126720	22				18	1	282·5
132480	23				18	14	355
133000	23	1	0	40	19		
138240	24				19	11	427·5
140000	24	3	5	20	20		
144000	25				20	9	62·5
147000	25	6	2	0	21		
149760	26				21	6	135
154000	26	8	6	40	22		
155520	27				22	3	207·5
161000	27	11	3	20	23		
161280	28				23	0	280
167040	29				23	13	352·5
168000	29	2	0	0	24		
172800	30				24	10	425
175000	30	4	4	40	25		
178560	31				25	8	59
182000	31	7	1	20	26		
184320	32				26	5	131·5
189000	32	9	6	0	27		
190080	33				27	2	204
195840	34				27	15	276·5
196000	34	0	2	40	28		
201600	35				28	12	149
203000	35	2	7	20	29		
207360	36				29	9	421·5
210000	36	5	4	0	30		
230400	40				32	14	275
280000	48	7	2	40	40		
288000	50				41	2	125
345600	60				49	5	412·5
350000	60	9	1	20	50		
403200	70				57	9	262·5
420000	72	11	0	0	60		
460800	80				65	13	113
490000	85	0	6	40	70		
518400	90				74	0	400·5
560000	97	2	5	20	80		
576000	100				82	4	250·5
630000	109	4	4	0	90		
645120	112				92	2	245
700000	121	6	2	40	100		
784000	136	1	2	40	112		

FRENCH DECIMAL WEIGHTS, AND THEIR EQUIVALENTS IN TROY AND
AVOIRDUPOIS WEIGHTS.

FRENCH METRICAL WEIGHTS.																
Myriogramme.	Kilogramme.	Hectogramme.	Decagramme.	Gramme.	Decigramme.	Centigramme.	Milligramme.	Equivalents in Troy Weight.				Equivalents in Avoirdupois Weight.				Equivalents in Troy Grains.
								lbs.	oz.	drs.	grs.	lbs.	oz.	troy grs.		
							1								0154	
						1	10								1543	
					1	10	100				1·5		1·5		1·5434	
				1	10	100	1000				15·4		15·4		15·434	
		1	10	100	1000	10000	100000			2	34		154		154·340	
	1	10	100	1000	10000	100000	1000000	3		1	43		3	230·9	1543·402	
	1	10	100	1000	10000	100000	1000000	2	8	1	14	2	3	121·5	15434·023	
1	10	100	1000	10000	100000	1000000	10000000	26	9	4	20	22	0	340	154340·234	

TABLES OF MEASURES OF CAPACITY.

APOTHECARIES' OR WINE MEASURE.

(Adopted in the United States and Dublin Pharmacopæias.)

				Equivalents in cubic inches.	Equivalents in Troy grains of distilled water at 62° Fahr.
1 minim, ℥	-	-	-	·00376	= 0·95
60 =	1 fluid drachm, ℥	℥	-	·2256	= 56·95
480 =	8 =	1 fluid ounce, ℥	℥	1·8047	= 455·6075
7680 =	128 =	16 =	1 pint, O,	28·8750	= 7289·72475
61440 =	1024 =	128 =	8 = 1 Cong.	231·0000	= 58317·798

IMPERIAL MEASURE.

				Equivalents in Avoirdupois weight.	Equivalents in Troy weight.
				Of distilled water at 62° Fahrenheit.	
1 pint	-	-	-	1·25 lb.	8750 grains.
2 =	1 quart	-	-	2·5 "	17500 "
8 =	4 =	1 gallon	-	10· "	70000 "
16 =	8 =	2 =	1 peck	20· "	140000 "
64 =	32 =	8 =	4 = 1 bushel	80· "	560000 "
512 =	256 =	64 =	32 = 8 = 1 quarter	640· "	4480000 "

APOTHECARIES' MEASURE.

(Adopted by the London and Edinburgh Colleges.)

				Equivalents in cubic inches.	Equivalents in Troy grains.
1 minim, \mathfrak{N}	-	-	-	·00361	0·91
60 =	1 fluid drachm, $\mathfrak{f}\mathfrak{3}$	-	-	·21662	54·7
480 =	8 = 1 fluid ounce, $\mathfrak{f}\mathfrak{3}$	-	-	1·73296	437·5
9600 =	160 = 20 = 1 pint, O	-	-	34·65925	8750·
76800 =	1280 = 160 = 8 = 1 gallon, Cong.	-	-	277·27400	70000

FRENCH MEASURES OF CAPACITY.

	English cubic inches.	Wine or U. S. Phar- macopœia measure.
Millilitre - -	·0610	16·2318 minims
Centilitre - -	·6103	2·7053 fluid drachms
Decilitre - -	6·1028	3·3816 fluid ounces
Litre - -	61·028	2·1135 pints
Decalitre - -	610·28	2·6419 gallons
Hectolitre - -	6102·8	26·4190 “
Kilolitre - -	61028·	264·1900 “
Myrialitre - -	610280·	2641·9000 “

The tables of weights and measures introduced above, have been chiefly taken from Mr. Redwood's edition of Gray's Supplement to the Pharmacopœia. Although the author did not deem it necessary to introduce tables of weights, measures, and specific gravities into this work, yet the editor believes that in a practical treatise to which constant reference will be made, and which, it is presumed, will be always at hand, these tables should be found. The use of troy weights by the pharmacutists of the United States in making the preparations of the Pharmacopœia, is very limited, and by far the larger number have none of these weights above the denomination of two drachms. To these, therefore, the table of equivalents will be especially valuable.—W. P.]

DETERMINATION OF SPECIFIC GRAVITIES.

The pharmacist has frequent occasion to refer to specific gravity, as a distinctive character of bodies, and it is important that he should be able to perform with facility the operations by which this character is determined.

All bodies are assumed to admit of compression and expansion:

their solid and impenetrable particles, therefore, are not in absolute contact, the distances varying under different circumstances. *Mass*, expresses the number of material particles contained in a body; and *density* represents the relation of the mass, that is, of the number of particles, or quantity of matter, to the volume, or space which the body occupies. Hence, *density* means comparative mass.

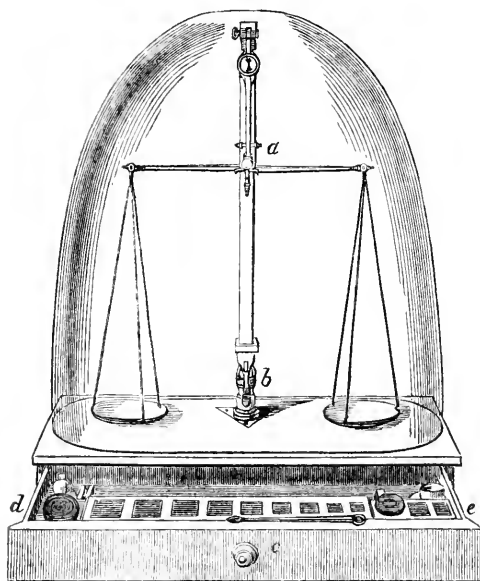
The measure of the gravitating force of a body, expressed with relation to some known standard, which serves as a unit, is the *absolute weight* of the body. The amount of this weight will be in direct proportion to the mass; it has no fixed relation to the volume. *Specific gravity*, on the other hand, expresses the relation of the weight to the volume of the body. A little observation would soon show that every body occupying a given space, has a weight *specific*, or peculiar to itself. Hence, the comparative weights of equal volumes of different bodies, are called their *specific gravities*.

The figures used for indicating specific gravities, may, with equal propriety, be applied to indicate density; and they are thus frequently employed indifferently, to denote either density or specific gravity.

The process for taking the specific gravity of a body consists in estimating the weight of a given volume of it, as compared with that of an equal volume of some other body, taken as the unit or standard of comparison. *Pure water* is used as the standard of comparison for solids and liquids, and *atmospheric air* for gases.

1. *The specific gravity of a solid substance insoluble in water* is determined by first weighing it in the usual manner, with an accurate balance, suspended in the air, then attaching a slender silken thread to it, and weighing it in water, and finally dividing the weight in air by the difference between the weight in air and the weight in water. Figs. 36 and 37, represent the appropriate balance and other apparatus for performing the process. The body, the specific gravity of which is to be determined, is weighed in the balance, fig. 36, and its weight carefully noted. One of the pans of the balance is then removed, and a pan, such as *f*, fig. 37, with short strings and a small hook at the bottom of the pan, is substituted for it, and the equilibrium adjusted. The substance under operation is attached to a fine silken thread, a horse-hair, or very thin platinum wire, as shown at *h*, fig. 37; this is then fixed to the hook at the bottom of the small pan (*f*), and a glass vessel, such as *g*, nearly filled with distilled water, being placed under it, the suspended body (*h*) is immersed in the water, and its weight taken under these circumstances. The object in thus weighing the body in water is, to ascertain the weight of a volume of

Fig. 36.



APPARATUS FOR TAKING SPECIFIC GRAVITIES.

Fig. 37.

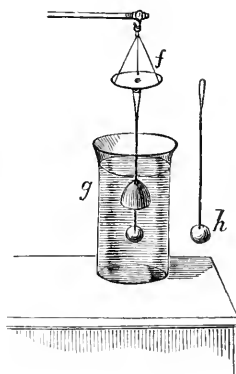


Fig. 38.



water equal to that of the body immersed. The process is founded upon the well-known facts, that a solid body, such as a piece of glass or metal, that is impervious to water, on being immersed in that liquid, displaces a volume of water equal to that of the body so immersed; and that the surrounding liquid exercises a pressure upwards, upon such body, equivalent to the weight of the volume of water displaced. Thus the weight of a body weighed as above in water, is equal to the absolute weight of the body, *minus* the weight of an equal volume of water; and, therefore, on deducting the weight of the body in water from its weight in air, the quotient will be the weight of a volume of water equal to that of the body so weighed. We thus obtain, first, the absolute weight of the body, and, secondly, the weight of an equal volume of water. The specific gravity is obtained by dividing the former by the latter.

Thus, a leaden bullet is found to weigh 398 grains in air; when immersed in water, its weight is 362·4 grains, and the difference between these two weights, namely, 35·6 grains, is the weight of the volume of water displaced by the bullet, or of a volume of water equal to that of the bullet. The volume of water being taken as unity, the specific gravity of the bullet is found by the following equation:—

35·6 : 1 : : 398 : 11·176, the specific gravity of the bullet.

2. In taking the specific gravity of a *solid substance lighter than water*, some modification of the process is required, but we have, nevertheless, the same preliminary points to determine; first, the weight of the substance in air; and, secondly, the weight of an equal volume of water. This may be illustrated by describing the method of taking the specific gravity of a piece of wax. The weight of the wax in air is 105·4 grains. On immersing the wax in water, two pressures are exerted—a pressure downwards, equal to the gravity or weight of the wax, and a pressure upwards, equal to the weight of the volume of water displaced by the wax; but the specific gravity of water being greater than that of wax, the upward pressure preponderates, and the wax rises to the surface. Thus we find that a volume of water equal to that of the wax, weighs as much as the wax, and something more. We must ascertain how much more, and this is done in the following manner: some body heavier than water, and the weight of which in water is known, is attached to the wax, and the two bodies are weighed in water together. A piece of lead may be used for this purpose. The arrangement is represented in fig. 37, where a leaden bullet, attached to a conical piece of wax, and immersed in the water, is shown. The lead alone weighs 378 grains in water; with the wax attached to it, the weight in water is 372·4 grains, making a difference of 5·6 grains, and this 5·6 grains is equal to the excess of the upward over the downward pressure of the wax when immersed in water. Thus, a volume of water equal to that of the wax weighs 5·6 grains more than the wax, or $105·4 + 5·6 = 111$ grains.

Then, $111 : 1 : : 105·4 : 0·949$, the specific gravity of the wax.

3. It sometimes happens that the solid substance, the specific gravity of which is to be determined, is *in powder*, or *in several small particles*. In such cases it is found convenient to proceed as in the following method of taking the specific gravity of calomel.

100 grains of calomel are introduced into a specific gravity bottle which holds 1000 grains of distilled water; the bottle is now filled up with water, and the weight of the contents is found to be 1083·7 grains; deducting the weight of the calomel (100 grains) from this, the remainder (983·7 grains) will be the weight of the water in the bottle, and the difference (16·3 grains) between this and 1000 grains, the weight of the whole contents of the bottle when filled with distilled water, is the weight of a volume of water equal to the volume of the calomel.

Then, $16·3 : 1 : : 100 : 6·13$, the specific gravity of the calomel.

If the substance be in several fragments, but not in fine powder, the process may be conducted as follows :

After having weighed the fragments in air, the small glass bucket (fig. 39) is suspended from the bottom of the pan *f*, immersed in the water, and the equilibrium adjusted; the fragments are then put into the bucket and thus weighed in water. In this way the two results required for the equation are obtained.

Fig. 39.

SPECIFIC
GRAVITY
BUCKET.

4. In taking *the specific gravity of substances soluble in water*, other modifications of the process are required. Sometimes the substance may be covered with a thin coating of varnish, so as to protect it from the action of the water. This method answers very well for blue pill, which may be brushed over with a strong tincture of mastic, and then proceeded with as in the case of the lead. In other instances, however, it is necessary to pursue a different course. Thus, any powder that is soluble in water, must have its specific gravity taken, in the first instance, with reference to some liquid in which it is not soluble. Spirit of wine, oil of turpentine, or olive oil, may be used in such cases. The process may be illustrated by describing the method of taking the specific gravity of guano in oil of turpentine. In the first place the specific gravity of the oil of turpentine is ascertained to be 0.874. Then 100 grains of guano are introduced into a specific gravity bottle, as in the case of the calomel; and the bottle being filled up with oil of turpentine, the weight of the contents is found to be 922.7 grains, from which deducting 100 grains, the remainder (822.7 grains) will represent the oil not displaced by the guano, and this deducted from 874 grains, the quantity of oil the bottle is capable of holding, leaves 51.3 grains as the weight of a volume of oil of turpentine equal to that of the guano. Now, $874 : 51.3 :: 1000 : 58.7$, the weight of a volume of water equal to that of the guano.

Then $58.7 : 1 :: 100 : 1.7$, the specific gravity of the guano.

The methods by which *the specific gravities of liquids* are usually determined, may be divided into two classes:—

1st. Those which consist in filling any suitable vessel with the liquid to be estimated; ascertaining the weight of the contents, and dividing this by the weight of the same volume of water.

2d. Those which consist in displacing a portion of the liquid, by some solid body floating in it, and estimating the specific gravity according to the weight and volume of the substance immersed, as compared with its immersion in water.

In the first case, the instruments employed are a *specific gravity bottle* and an ordinary *balance*.

In the second case, the instruments used may be comprehended under the general terms of *hydrometers*, or *aréometers*. These, however, are distinguished from each other, for there are many varieties of them, by different names, according to the particular purposes for which they are respectively intended, or from some peculiarity in their construction.

5. *The specific gravity bottle* affords the most accurate means of determining the comparative densities of liquids. It consists usually of a globular bottle (fig. 40) with a flat bottom, and a slender neck, which holds exactly 1000 grains of distilled water at a certain fixed temperature. It is very easy at any time to test the accuracy of one of these bottles by a single experiment, and having ascertained that the bottle is correctly adjusted with regard to distilled water, the indications afforded with any other liquid will be equally trustworthy.

Fig. 40.



SPECIFIC GRAVITY
BOTTLE.

Every chemist ought to prepare his own specific gravity bottle for use, and he will then know what degree of confidence can be placed in its indications. Small flasks adapted for the purpose, are made by the glass-blowers, and sold for about a shilling each. One of these flasks is carefully counterpoised in the balance, and 1000 grains of pure distilled water is put into it. The water should fill the globular part of the flask, and extend about two-thirds up the neck. The surface of the water in the neck of the flask will be concave, this being caused by the capillary attraction of the glass. The water must now be brought to the temperature of 62° Fahr., and when it is at this temperature a mark is to be made by scratching the glass with a file, indicating the height at which the water stands. It is customary to make two scratches, one opposite the top, and the other opposite the bottom, of the curve formed by the surface of the water, as seen in a horizontal line from the eye of the operator.

The weight, in grains, of the quantity of any liquid filling this bottle to the mark, will indicate its specific gravity. In the use of the specific gravity bottle there are two points which require particular attention:—the *first* is, that the bottle should be perfectly clean and dry before introducing the liquid to be tried; and the *second* is, that the liquid, when the bottle is filled to the proper mark with it, should be exactly at the temperature at which the original adjustment of the

bottle with distilled water was made. It is sometimes found difficult to dry a specific gravity bottle quickly, when required to be used for several successive operations; and also to get it perfectly clean when it has been used for oils. In such cases, the desired object may be attained by introducing some clean, dry, and warm sand, free from dust, shaking this out briskly, and repeating the process until the effect is completed. In the absence of sand suitable for the purpose, or in case that method should not succeed, some oil of vitriol may be put into the flask previously containing a few drops of water, so as to cause considerable elevation of temperature, and after bringing the hot acid into contact with every part of the surface of the glass by turning the flask in different directions, continuing the action until all organic matter has been removed, the acid is poured out, and the flask well washed with water. After being washed, it should be drained for a few minutes, and then placed on the sand-bath until it has become hot. A small glass tube, of four or five inches in length, which passes freely through the neck of the flask, is now introduced, and the mouth being applied to the end of the tube, air is drawn into the lungs so as to establish a current and constant change of air in the bottle. In this way it may be cleaned and dried in a few minutes.

With regard to the temperature at which the specific gravity bottle is to be used, it must be borne in mind that the London Pharmacopœia directs specific gravities to be always taken at 62° Fahr., and therefore every English pharmacist ought to have his specific gravity bottles adjusted to this temperature, at which, also, he should of course use them. The manufacturers of these instruments, unless they receive express instructions to the contrary, usually adjust them at 60° Fahr.

Hydrometers, or *arëometers*, are floating instruments, and their application for the purpose of determining the specific gravities of liquids, depends upon the fact that a body immersed in any liquid sustains a pressure from below upwards, equal to the weight of the volume of liquid displaced by such body.

The use of hydrometers for determining the specific gravities of liquids, has been traced back to a period about 300 years before Christ; an instrument of this kind being described as the invention of Archimedes, the Sicilian mathematician. It subsequently fell into disuse, but was again brought into notice by Basil Valentine.

There are two kinds of hydrometers, which may be taken as types for all the different varieties in regard to construction:—

1st. Those which are always immersed into the liquids to be tried, to the same depth, and to which weights are added to adjust the in-

strument to the density of any particular liquid. Of this description are Fahrenheit's, Nicholson's, and Guyton de Morveau's hydrometers. These instruments indicate the weight of a given volume of any liquid.

2d. Those which are always used with the same weight, but which sink into the liquids to be tried, to different depths, according to the densities of the liquids. These usually have graduated scales attached to their stems. Of this description are the common glass hydrometers generally, including those of Baumé, Cartier, Gay-Lussac, Twaddle, Zanetti, &c., and the specific gravity beads. These instruments indicate the volume of a given weight of any liquid.

Sikes's and Dicas's hydrometers combine some of the principles of both types, having movable weights and graduated scales.

Hydrometers may also be divided into two classes, as follows:

1st. Those having a general application for determining the comparative densities of any liquids.

2d. Those intended for special application, as for estimating the comparative strengths of spirits, or the comparative densities of syrups, oils, &c.

Fahrenheit's, Nicholson's, Guyton de Morveau's, and the common glass hydrometers, including Baumé's, Cartier's, Twaddle's, Zanetti's, and the specific gravity beads, belong to the first class.

Gay-Lussac's, Sikes's, and Dicas's hydrometers, the saccharometer, urinometer, clæometer, and galactometer, belong to the second class.

6. *Fahrenheit's hydrometer* consists of two glass bulbs blown on a tube, like a common hydrometer, excepting that the upper bulb is larger, and the stem is terminated at the top in the form of a cup or funnel. The lower bulb is loaded with mercury, but not so as to cause the entire immersion of the instrument, when put into water, without the addition of weights to the cup at the top of the stem. There is a mark about the middle of the stem, which is the point at which the hydrometer is made to float, by putting the requisite weights into the cup.

7. *Nicholson's hydrometer* is a modification of Fahrenheit's. It is made of brass, and consists of a hollow globe, to which a very slender stem, surmounted by a cup, is attached; on the opposite side of the globe there is another cup, fixed in a kind of stirrup and loaded, so that this shall always be the lowest point of the instrument when immersed in any liquid. The form of this instrument therefore differs from that of Fahrenheit's in the lower bulb of the latter being replaced by the loaded cup. There is a mark on the stem indicating the point at which the hydrometer is to be made to float by the proper adjust-

ment of the weights. The weight of the loaded instrument, when sunk to the proper point, is the weight of the volume of liquid displaced by it. It gives, therefore, the relative weights of equal volumes of the liquids into which it is introduced. This instrument is also sometimes called the *Gravimeter*; it is usually made to displace 3000 or 4000 grains of water, and is sensible to the tenth of a grain in this quantity.

This instrument is applicable, also, for taking the specific gravities of solid substances. By placing the solid body in the cup at the top of the stem, and then adjusting the additional weights required to sink the hydrometer, the weight of such solid body in air is ascertained; then, by placing the solid body in the lower cup, immersed in the water, and again adjusting the weights as before, the weight of the body in water is ascertained; and from these the specific gravity is calculated, as in the other cases described.

Baumé's hydrometers are used extensively in this country as well as in France, and are applicable for all kinds of liquids. There are two distinct instruments, one for liquids lighter than water, and the other for liquids heavier than water. The latter is, for distinction, called the *acidometer* or *saccharometer* (*pèse-acide* or *pèse-sirop*); the former, the *spirit hydrometer* (*pèse-esprit*).

8. *Baumé's acidometer* is made in the form of the common hydrometer, the outline of which is represented in fig. 41. It consists of a glass tube terminated at the lower end by two bulbs, the lowest bulb being much smaller than the other, and intended to contain the ballast with which the instrument is loaded. The scale is marked on a slip of paper, or of ivory, fixed in the tube, and is adjusted in the following manner:—The top of the tube being open, the slip of paper on which the scale is to be marked is put into the stem, and the instrument is then immersed in pure distilled water; quicksilver is now dropped into the lower ball until the instrument sinks so low in the water that only the top of the stem remains above the surface, and a mark is made on the glass denoting exactly the point to which it sinks. The instrument is now taken out of the pure water, and put into a solution of fifteen parts of common salt in eighty-five parts of distilled water, this solution being at the same temperature as the water in which the instrument was previously immersed. The point to which it sinks in this solution is to be marked on the stem as before, and the distance between the two marks being taken with a pair of compasses, and

Fig. 41.

COMMON
HYDRO-
METER.

transferred to the slip of paper, the first is made the zero or 0, and the other the 15th degree of the scale. This distance being divided into fifteen equal parts or divisions, each division is called a degree, and the scale is completed by adding as many more degrees as the length of the stem will admit of. This being done, the slip of paper is again introduced into its place, and so fixed that the zero (0) of the scale shall be exactly opposite the first mark made on the glass. The end of the stem is now sealed with the flame of a blow-pipe.

9. *Baumé's spirit hydrometer* is similar in form to the acidometer, but the weight of the instrument and the scale are different. In this case, the hydrometer is first immersed in a solution of ten parts of common salt in ninety parts of water; but it is made to float, so that the greater part of the stem shall be above the surface of the water. This point is marked, and the instrument is then transferred to pure distilled water, when another mark is made. The distance between these marks is made ten degrees of the scale, which are divided with the compasses, and marked on the slip of paper, as in the other case, the floating-point in the solution of salt being made the zero, and the degrees carried upwards from this point.

The temperature at which these instruments were originally adjusted by Baumé, was 10° Reaumur, or $12\cdot5$ centigrade; but those made in England are usually adjusted at 60° Fahrenheit. It is sometimes important to be aware of this difference, and to bear in mind that in the London Pharmacopœia specific gravities are directed to be taken at 62° .

10. *Cartier's hydrometer* is much used in France. It is only applicable for liquids lighter than water. This instrument is a modification of Baumé's spirit hydrometer, the form of the instrument being the same, and the same point being taken as the zero of the scale; but the space which in Baumé's scale is divided into 32° , is in Cartier's divided into 30° .

It is becoming the common practice in this country to have the scales of hydrometers marked with the specific gravities intended to be indicated, and this is by far the most convenient kind of hydrometer for general use.

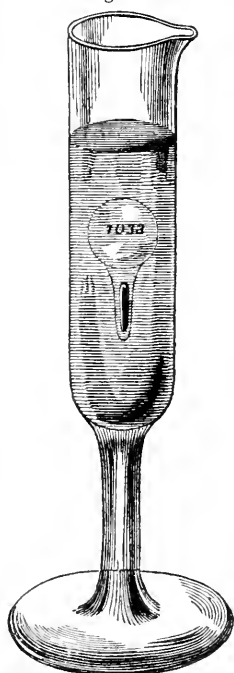
11. *Twaddle's hydrometers* are much used by manufacturers for estimating the strength of saline and other solutions. They are made of glass like the common hydrometers, and are sold in sets of six. Each degree on the scale is equal to 0.005 of specific gravity, so that the specific gravity of a liquid is found with these hydrometers, by multiplying the number of degrees indicated by 5, and adding 1000.

Thus, 10° by Twaddle's hydrometer, $\times 5 + 1000 = 1.050$ specific gravity.

12. *Zanetti's hydrometers*, which are made at Manchester, are also sold in sets of six. With these the specific gravity is got by adding a cipher to the number of degrees indicated.

13. *Specific gravity beads*, sometimes called *Lovi's beads*, are hollow sealed globes of glass, about the size of small pistol-bullets. Each bead is a small hydrometer, intended to indicate one fixed density, by its remaining half-way between the top and bottom of the liquid into which it is introduced, as shown in fig. 42. These beads are sold in sets, each one being marked with the specific gravity it is to indicate at a certain fixed temperature. They are very useful in making mixtures of any required densities, as, for instance, in making test acids. The bead represented in the drawing, indicates the density of test sulphuric acid, one thousand grain-measures of which will saturate as many grains of alkali as represent the equivalent; for instance, 70 grains of carbonate of potash, 54 grains of carbonate of soda, or 17 grains of ammonia. The test acid is, therefore, readily made, by carefully adding pure oil of vitriol to distilled water, until the bead remains in the mixture, when at a temperature of 60° Fahr., as shown in the drawing, neither sinking to the bottom, nor rising to the surface. The specific gravity of *test sulphuric acid*, made as above, is 1.033.

Fig. 42.



SPECIFIC GRAVITY BEAD.

Fig. 43.

GAY-LUSSAC'S
ALCOHOMETER.

Gay-Lussac's alcoholometer, fig. 43, is frequently employed in France; it is adapted only for estimating the strength of spirits. The instrument is made like a common glass hydrometer, the scale of which is divided into 100 parts or degrees. The lowest division, marked 0, at the bottom of the scale, denotes the specific gravity of pure water at a temperature of 15° cent., or 59° Fahr., and the highest division, at the top of the scale, the specific gravity of what was considered absolute alcohol at the same temperature, namely, spirit of sp. gr. .796. The

intermediate degrees indicate the number of volumes of such alcohol in 100 volumes of the spirit tried. The instrument is accompanied by a table for correcting the numbers marked on the scale, when it is used at any other temperature than that of 15° cent.; and there is generally a thermometer inserted in the lower part of the instrument, as shown in the drawing.

15. *Sikes's hydrometer* is used in the collection of our spirit revenue. It consists of a spherical ball or float, with an upper and a lower stem, made of brass, (*a, b, c*, fig. 44). The upper stem (*b*) has ten principal divisions, numbered 1, 2, 3, &c., which are each subdivided into five parts. The lower stem (*c*) is made conical, and has a pear-shaped loaded bulb at its lower extremity. There are nine movable weights (*b, b, b*, fig. 45), which have the form of circular disks, and numbered 10, 20, 30, and so on to 90. Each of the circular weights is cut into its centre, so that it can be placed on the conical

Fig. 44.

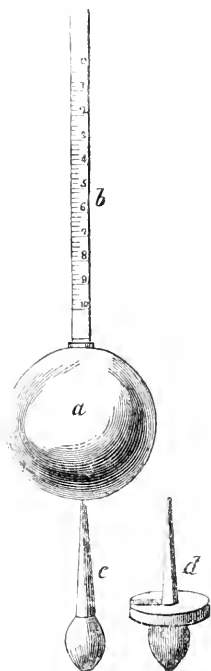
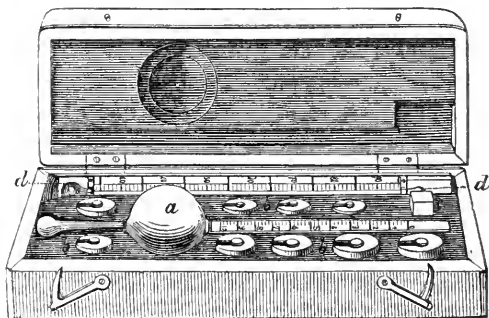


Fig. 45.



SIKES'S HYDROMETER.

stem (*c*) at the small end, and slid down to the bulb, where it becomes fixed in consequence of the enlargement of the cone, as shown at *d*. The instrument is adjusted to strong spirit, specific gravity .825 at 60° Fahr., this being accounted as standard alcohol. In this spirit the instrument floats at the first division, 0 or zero, without a weight. In weaker spirit, having a greater density, the hydrometer will not sink so low, and if the density be much greater, it will be necessary to add one of the weights to cause the entire immersion of the bulb of the instrument. Each weight represents so many principal divisions of the stem as its number indicates; thus the heaviest weight, marked 90, is

equivalent to ninety divisions of the stem, and the instrument with this weight added, floats at 0 in distilled water. As each principal division on the stem is divided into five, the instrument has a range of 500 degrees between standard alcohol, sp. gr. $\cdot 825$, and water.

There is a line on one of the side faces of the stem *b*, near to division 1 of the drawing, at which line the instrument, with the weight 60 attached to it, floats in spirit exactly of the *strength of proof* at a temperature of 51° Fahr.; and if the square weight *c* be placed on the top of the stem *b*, the weight 60 still remaining below, the instrument will float at the above line in distilled water of the same temperature. The square weight (*c*) being exactly one-twelfth part of the total weight of the hydrometer and weight 60, the above indication is in conformity with the definition of *proof spirit* given in the act of Parliament, "proof spirit to weigh, at 51° temperature, exactly twelve-thirteenth parts of an equal bulk of distilled water."

In using this instrument it is immersed in the spirit, and pressed down by the hand to 0, till the whole divided part of the stem be wet. The force of the hand required to sink it will be a guide in selecting the proper weight. Having taken one of the circular weights which is necessary for this purpose, it is slipped on the conical stem. The instrument is again immersed and pressed down as before to 0, and is then allowed to rise and settle at any point of the scale. The eye is then brought to the level of the surface of the spirit, and the part of the stem cut by the surface, *as seen from below*, is marked. The number thus indicated by the stem is added to the number of the weight, and the sum of these, together with the temperature of the spirit, enables the operator to find, by reference to a table which accompanies the instrument, the strength of the spirit tested.

The number thus indicated by the stem is added to the number of the weight employed, and with this sum at the side, and the temperature of the spirits at the top, the strength *per cent.* is found in a table which accompanies the hydrometer. The strength is expressed in numbers denoting the excess or deficiency *per cent.* of proof spirit in any sample, and the number itself, having its decimal point removed two places to the left, becomes a factor, whereby the gauged contents of a cask or vessel of such spirit being multiplied, and the product being added to the gauged contents if over proof, or deducted from it if under proof, the result will be the actual quantity of proof spirit contained in such cask or vessel.

16. *Dicas's hydrometer* is similar in construction to Sikes's, and it

is used in a similar manner, with the same result, indicating the relation of the spirit tried to standard proof spirit.

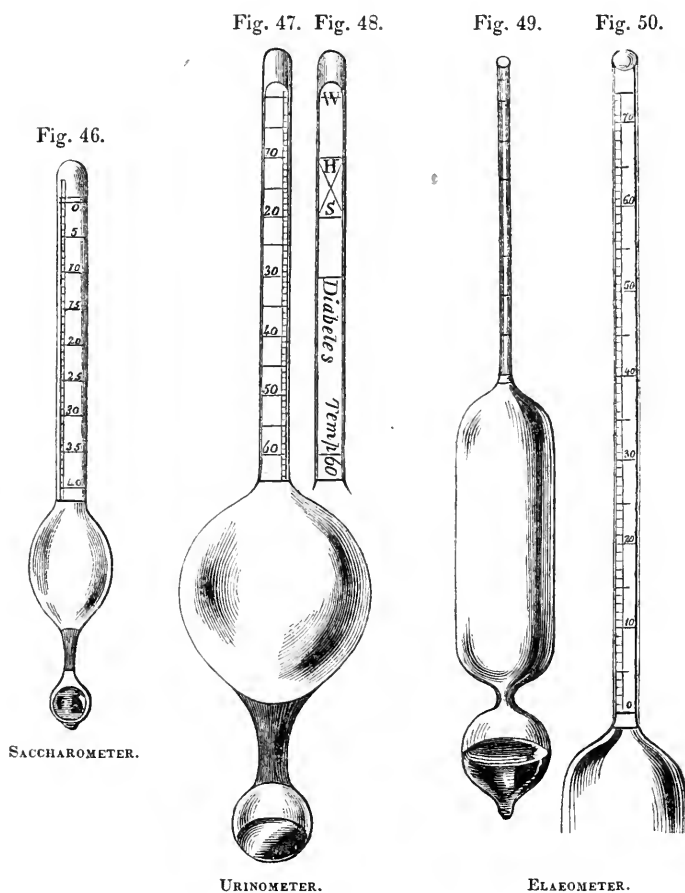
It is the practice in commerce to designate the strength of spirit as so many degrees above or below proof, the government having fixed upon what is called *proof spirit* as the standard in comparison with which the strength of all spirit shall be estimated. The term *proof* is said to have been derived from the ancient practice of trying the strength of spirit by pouring it over gunpowder in a cup, and then setting fire to the spirit; if, when the spirit had burned away, the gunpowder exploded, the spirit was said to be *over proof*; if, on the other hand, the gunpowder failed to ignite, in consequence of the water left from the spirit, it was said to be *under proof*. The weakest spirit capable of firing gunpowder in this way was called *proof spirit*; but it requires a spirit nearly of the strength of what is now called rectified spirit to stand this test. The *standard proof spirit* of the excise is defined by law (56 Geo. III. cap. 140) to be "*that which at a temperature of 51°, by Fahrenheit's thermometer, weighs exactly twelve-thirteenth parts of an equal measure of distilled water.*" This will have a specific gravity of $\cdot 923$ at 51° Fahr., or about $\cdot 920$ at 60° Fahr. The *standard alcohol* of the excise is spirit, the specific gravity of which is $\cdot 825$ at 60° Fahr. By "spirit 60 degrees over proof" is understood a spirit, 100 measures of which, added to 60 measures of water, will form *standard proof spirit*, sp. gr. $\cdot 920$. By "spirit 10 degrees under proof" is understood a spirit, 100 measures of which, mixed with 10 measures of standard alcohol, sp. gr. $\cdot 825$, will form *standard proof spirit*.

17. *Saccharometers* are hydrometers intended for determining the density of syrups. They are usually made and graduated in the same manner as Baumé's acidometers, and differ only from these in being made smaller. Fig. 46 represents one of these instruments drawn to its real size; but they are sometimes made larger than this. It floats at 30°, in a solution, the specific gravity of which is 1.26, and this is the density of simple syrup when boiling; therefore, if the instrument floats at 30° in a solution of sugar, when boiling, it is inferred that such solution will be exactly saturated when cold. The scale is sometimes graduated so as to indicate the proportion of sugar in the solution.

18. The *urinometer* is a small hydrometer, originally suggested by Dr. Prout for estimating the density of urine. The scale is divided into 60 degrees, the zero being the point at which it floats in distilled water. Fig. 47, represents the instrument drawn to its real size.

The numbers on the scale, added to 1000, the assumed specific gravity of water, give the specific gravities at the respective points. Thus, supposing the number cut by the surface of the fluid to be 30, this indicates a specific gravity of 1030. Fig. 48 shows the reverse side of the scale. The letters, H. S. on this side signify *healthy standard*, which ranges from 10° to 20° of the scale. The space from 30° to 60° is marked *diabetes*, the urine of diabetic patients having generally a density ranging between these points.

19. The *elaëometer* (fig. 49) of M. Gobley, of Paris, is a very delicate glass hydrometer, intended for testing the purity of olive oil or oil of almonds, by determining their densities. The 0 or zero of



the scale, is the point at which the instrument floats in *oil of poppy seeds*. The point at which it floats in *pure olive oil*, is made the 50th

degree, and the space between these two points is divided into 50 equal parts and numbered accordingly. It floats at 38° or $38\frac{1}{2}^{\circ}$ in pure oil of almonds. Fig. 50 is drawn to the real size of the scale of the instrument.

20. The *galactometer* is similar in construction to the *elaëometer*, but is intended for determining the quality of milk. There are two scales which have been attached to the galactometers; one indicates the different qualities of cow's-milk, according to its density; the other is intended to distinguish the milk of one animal from that of another animal. These instruments were originally suggested by Cadet de Vaux, and subsequently improved by Dinocourt, 7, Quai St. Michel, Paris, by whom they are made.

21. There are other means besides those above described for taking the specific gravities of liquids. Thus on weighing a solid body, first in air and then in water (as described in process 1), the weight of a volume of water equal to the volume of the solid substance employed, is ascertained; and if this be repeated, using the same solid body, but immersing it in any other liquid besides water, the weight of an equal volume of such other liquid is determined; then the latter

Fig. 51.



result divided by the former, will give the specific gravity of the second liquid employed. This method is well adapted for taking the specific gravity of any liquid, where only a small specimen of it is available for the purpose. A small piece of glass or of platinum, suspended by a hair, may be used as the solid body in such cases. A bit of platinum, of the size of a swan-shot, and half a drachm of liquid, contained in a small test tube, will afford a tolerably accurate result with a good balance. The glass cone (fig. 51) is one of the appendages to the balance (fig. 36), and is intended to be used in the manner above described for taking specific gravities.

Dr. Mohr describes an arrangement of apparatus, which is shown in figs. 52, 53, and 54, for determining the densities of small quantities of liquids.

In the first place, the beam and one of the pans of a very good dispensing balance are suspended from a stand, as shown in fig. 52. One arm of the beam, from the point of suspension to the point from which the pan was originally suspended, is accurately divided into ten equal parts, which are numbered from 1 upwards, commencing from the centre of the beam. In the next place, a small glass tube, of which fig. 53 is the real size, is partly filled with mercury, and its open end is then drawn out in the flame of a blow-pipe and bent

so as to form a hook. This tube is suspended by a very slender platinum wire from the end of the graduated arm of the balance, and is counterpoised by weights or a box of sand put into the pan at the opposite extremity. The loaded tube is immersed in distilled water, at the proper temperature, contained in a conical glass, such as that in fig. 52, or a cylindrical glass fixed in a stand, such as fig. 54. A piece of bent copper or brass wire is now loosely suspended from the same hook, to which the platinum wire holding the immersed tube

Fig. 52.

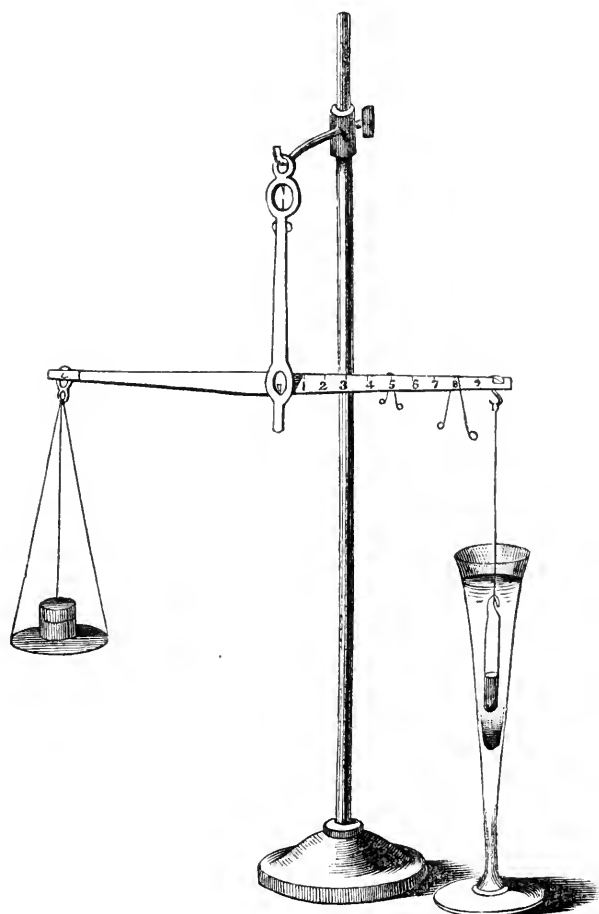


Fig. 53.



Fig. 54.



APPARATUS FOR TAKING SPECIFIC GRAVITIES.

is attached, and the weight of this is accurately adjusted by means of the pincers and file, so as to restore the equilibrium of the balance.

This wire will of course represent the weight of the water displaced by the immersed tube. When accurately adjusted it is to be bent to the form of those represented as suspended from the graduated arm of the balance. A second wire, of precisely the same weight as the first, and of similar form, is to be prepared; and also a third, which is to be made one-tenth the weight of either of the others. With these three wires all specific gravities up to 2.0 may be determined.

The apparatus is used in the following way:—The liquid to be tested is put into either of the glasses, and the suspended tube being immersed in it, one of the wires is placed on the beam and pushed along it until it is brought to a point at which it restores the equilibrium. If this point should lie between two of the divisions of the beam, as, for instance, between 8 and 9, and if the wire used be one of the heavier kind, it is to be placed at the lower of the two figures, that is at 8, and this will be the first decimal figure in the specific gravity of the liquid; the smaller wire is then put on to the beam and pushed along it until the equilibrium is again established, and the

Fig. 55.

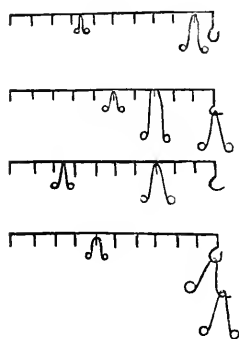


figure opposite which it rests will be the second decimal figure in the specific gravity.

In fig. 52, the wires indicate a specific gravity .850, the larger wire being at 8, and the smaller wire at 5. If the small wire, instead of being immediately over one of the divisions of the beam, should be at a point between two figures, its position must be measured by the eye, and represented by a third decimal figure; thus, if, instead of being at 5, the small wire were midway between 5 and 6, the specific gravity would be .855. When the

larger wire reaches the end of the beam, and is suspended from the hook to which the immersed tube is attached, this will indicate a specific gravity 1.0, or that of water, to which the instrument was adjusted; and the second large wire being now placed on the beam, densities above that of water may be indicated. Fig. 55 represents the method of placing the wires, and in the four cases illustrated the specific gravities which the positions of the wires indicate are expressed in figures placed opposite.

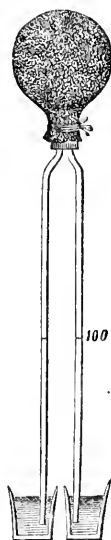
22. The principle of the syphon has been applied in the construction of an apparatus for determining the specific gravities of liquids. Two glass tubes of equal length are inserted into an Indian-rubber bag, as shown in fig. 56, or connected by means of a short brass tube,

bent twice at right angles, so as to form a syphon. In the space between the two limbs of the syphon is placed a scale divided into 1000 or any number of degrees. A stop-cock is fixed in the brass connecting-piece at the top of the syphon, by which the air can be exhausted, and any liquids into which the lower extremities of the tubes are immersed, made to ascend in the tubes. If one limb of the syphon be immersed in distilled water, and the other in any liquid the specific gravity of which is to be determined, contained in two glasses; and if the air be exhausted by first collapsing the Indian-rubber bag and then allowing it to expand, or by applying the mouth or a syringe to the tube if the other form of apparatus be adopted, so that the liquids, or at least one of them, shall rise nearly to the top of the syphon, the length of the columns thus sustained by the pressure of the external atmosphere, will be in inverse proportion to the specific gravities of the liquids. Then, water being taken as unity, the specific gravity of any other liquid in relation to it is easily ascertained. Thus, if water stands at 240° in one limb of the syphon, and oil of vitriol at 131° in the other, we ascertain the specific gravity of the oil of vitriol by the inverse rule of proportion, as follows:—

131 : 1 :: 240 : 1·845, the specific gravity of the oil of vitriol.

The specific gravities of gases and vapours are expressed with reference to atmospheric air as unity. As in the cases of solids and liquids, it is necessary to ascertain, first, the weight of a given volume of the gas or vapour under examination; and secondly, the weight of an equal volume of the substance to which it is to be compared,—in this case atmospheric air. These processes are rarely required to be performed by the pharmacist, and therefore will not be described here.

Fig. 56.



[RELATION BETWEEN SPECIFIC GRAVITIES, AND THE DEGREES OF
BAUME'S HYDROMETER FOR LIQUIDS HEAVIER THAN WATER.

Baumé.	Sp. Gr.	Baumé.	Sp. Gr.	Baumé.	Sp. Gr.
0	1·000	4	1·029	8	1·060
1	1·007	5	1·036	9	1·067
2	1·014	6	1·044	10	1·075
3	1·022	7	1·052	11	1·083

Baumé.	Sp. Gr.	Baumé.	Sp. Gr.	Baumé.	Sp. Gr.
12	1.091	33	1.298	54	1.601
13	1.100	34	1.309	55	1.618
14	1.108	35	1.321	56	1.637
15	1.116	36	1.334	57	1.656
16	1.125	37	1.346	58	1.676
17	1.134	38	1.359	59	1.695
18	1.143	39	1.372	60	1.715
19	1.152	40	1.384	61	1.736
20	1.161	41	1.398	62	1.758
21	1.171	42	1.412	63	1.779
22	1.180	43	1.426	64	1.801
23	1.190	44	1.440	65	1.823
24	1.199	45	1.454	66	1.847
25	1.210	46	1.470	67	1.872
26	1.221	47	1.485	68	1.897
27	1.231	48	1.501	69	1.921
28	1.242	49	1.516	70	1.946
29	1.252	50	1.532	71	1.974
30	1.261	51	1.549	72	2.000
31	1.275	52	1.566	73	2.031
32	1.286	53	1.583	74	2.059

RELATION BETWEEN SPECIFIC GRAVITIES, AND BAUME'S AND CARTIER'S
HYDROMETERS FOR LIQUIDS LIGHTER THAN WATER.

Baumé.	Cartier.	Sp. Gr.	Baumé.	Cartier.	Sp. Gr.
10	10.00	1.000	30	28.38	0.878
11	10.92	0.993	31	29.29	0.872
12	11.84	0.987	32	30.31	0.867
13	12.76	0.979	33	31.13	0.862
14	13.67	0.973	34	32.04	0.857
15	14.59	0.966	35	32.96	0.852
16	15.51	0.960	36	33.88	0.847
17	16.43	0.953	37	34.80	0.842
18	17.35	0.947	38	35.72	0.837
19	18.26	0.941	39	36.63	0.832
20	19.18	0.935	40	37.65	0.827
21	20.10	0.929	41	38.46	0.823
22	21.02	0.923	42	39.40	0.818
23	21.94	0.917	43	40.31	0.813
24	22.85	0.911	44	41.22	0.809
25	23.77	0.905	45	42.14	0.804
26	24.69	0.900	46	43.06	0.800
27	25.61	0.894	47	43.19	0.795
28	26.53	0.888	48	44.90	0.791
29	27.44	0.883			

CHAPTER III.

ON THE SOURCES AND MANAGEMENT OF HEAT, FUEL, FURNACES, FURNACE OPERATIONS, AND LAMPS.

[THE peculiar nature of caloric, and the laws and theories appertaining to it, do not come within the scope of a treatise on practical pharmacy. It is the application of this powerful agent in affecting the condition of matter destined for medicinal use, and the modes of directing and controlling its influence, by means of apparatus of various kinds, that more properly belong to this department. The operations of glowing, or heating to redness, with the kinds of furnaces most appropriate for the several purposes of pharmacy, together with lamps of various kinds, including gas-burners and steam-heating arrangements, with their applications to the pharmaceutical laboratory, will be treated of in detail.—W. P.]

FURNACE OPERATIONS.

OPERATIONS OF GLOWING OR HEATING TO REDNESS.

The heating of a body until it becomes luminous, is called *glowing* (gluhen) or *heating to redness*. All solid bodies, when they acquire a certain temperature, become luminous, and the temperature is often estimated by the intensity of the light which is emitted; thus the terms *red-heat*, *cherry-red-heat*, and *white-heat*, are used to designate degrees of temperature, which cannot be conveniently measured by the instruments commonly used for such purposes. *Red-heat* is the lowest temperature contemplated in these operations; it is produced by the slow combustion of fuel maintained in a furnace or stove without any strong draught of air. *White-heat* is the most intense heat that can be obtained in a furnace, aided by a powerful draught or artificial blast. *Cherry-red-heat* is intermediate between the two others; it is the most useful for many chemical purposes. Professor Daniell, by the use of his pyrometer, estimated the temperature at which solid bodies begin to be luminous, at between 800° and 900° of

Fahrenheit's scale; he has represented a *red-heat* as equal to 980° Fahr.; a *white-heat* may be represented as equal to about 3000° Fahr.; and a *cherry-red-heat* about midway between the two.

We shall have occasion here to treat of the practical means by which these degrees of heat may be obtained. As a general rule, it is considered desirable, in pharmaceutical laboratories, to avoid, as much as possible, having recourse to operations requiring these high temperatures, for as they occur but rarely, the fire has to be lighted expressly for each process, in a furnace previously cold, and therefore requiring some time and expenditure of fuel to get it into a state fit for use. On this account, and also on account of the loss incurred from the fracture of crucibles, and unavoidable waste of the materials operated upon, many substances which, in their preparation, were formerly heated to redness, are now prepared by a less expensive and troublesome process. Yet there still are cases in which recourse is obliged to be had to this method of operating, and therefore the implements for conducting it ought not to be wanting in a well-appointed laboratory.

Fuel.—*Charcoal* is the most convenient fuel to use in these operations. It ignites easily, will burn readily in stoves of all kinds, whatever their construction may be, and leaves no slag. It presents the advantages, therefore, of being more cleanly, and more easily managed, than other kinds of fuel; but on the other hand, it is more expensive, (especially in England,) and it burns away more quickly.

Common Mineral Coal is cheaper than charcoal; it requires a stronger draught to maintain its combustion, and it leaves slags and a greater amount of ash, which tend to block up the grate; it affords, however, a stronger heat.

Coke, that is, coal deprived of its gaseous and sulphurous constituents, affords, when the combustion is maintained with a sufficient draught or blast of air, a stronger heat than any other kind of fuel. It supports combustion for a long time, and therefore a fire does not require to be fed so often with this fuel as it would if charcoal were used, which is a great advantage in many operations. There is a marked distinction between a coke fire and a charcoal fire, which is worthy of notice. In a coke fire there is very little flame, and this scarcely extends beyond the fuel itself, while charcoal burns with a considerable flame, resulting from the combustion of carbonic oxide gas. The reason of this is, evidently, that the carbonic acid produced by the combustion is not so readily converted into carbonic oxide by passing through red-hot coke as through the more easily oxidisable

charcoal. From the same cause the heat is most intense in a coke fire at the place of the draught, while in a charcoal fire it is distributed more equally throughout. On this account, as well as for other reasons, a coke fire is economical, as there is a smaller consumption of fuel, arising from the production of carbonic oxide in the part of the furnace not used. Moreover, charcoal burns with a crackling noise, and throws off a great number of sparks, which are troublesome, and even dangerous to the eyes of the operator, an inconvenience not experienced in the use of coke; and as the latter burns only at a strong heat, the combustion soon slackens, and ceases when the blowing is suspended or the draught checked at the conclusion of a process, and the unconsumed fuel is thus saved for another operation.

[Anthracite is the densest form of fuel, and for nearly all the purposes of the pharmacist, requiring a long-continued strong heat it is applicable. The sulphurous fumes, which are evolved from it are objectionable in certain operations, in which cases coke or charcoal may be substituted.—W. P.]

There are two kinds of coke used in this country, which are distinguished as *gas-coke* and *oven-coke*. The former is obtained as a secondary product in the manufacture of coal-gas; the latter is made by a distinct process in ovens constructed expressly with a view to the production of a good heat-producing fuel. The properties of these two kinds of coke differ so considerably that they cannot be indiscriminately employed for the same purposes.

Gas-coke is much more easily combustible than *oven-coke*, that is to say, it burns at a lower temperature. When mixed with a small quantity of coal, it may be burned, as it frequently is burned, in open stoves, and even without this admixture it forms an excellent fuel for close stoves or furnaces, even for those in which there is not a strong draught.

Oven-coke can only be burned in furnaces having a strong draught; indeed, an artificial blast is generally required to insure its active combustion. When burned under these circumstances, however, the combustion is more enduring, and the heat produced more intense, than would be the case if *gas-coke* were used. It forms the best fuel, therefore, for air or blast furnaces, and is generally employed where intense heat is required, as, for instance, in the smelting of iron.

Wood, peat, or brown coal, if used in the processes now under consideration, are employed in a different manner from that adopted with the fuels previously noticed. The crucible containing the substance to be acted upon is not placed immediately in contact with the ignited

fuel, but merely exposed to the flame resulting from its combustion; these fuels, therefore, require a furnace of particular construction, which will be described hereafter. Peat and brown coal should be well dried before being used, and even then are only fit for use in these operations, when they burn with very little residue.

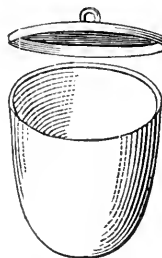
Crucibles.—In conducting the process of *glowing*, the substance to be heated to redness is generally put into a crucible. The crucibles

Fig. 57.



Hessian CRUCIBLE.

Fig. 58.



PORCELAIN CRUCIBLE.

Fig. 59.



PLATINUM CRUCIBLE.

used for this purpose have either round or triangular mouths. There is no particular reason for giving the preference to one rather than the other of these forms, unless it be that in some cases the round crucible may be better suited to the shape of the furnace into which it is intended to be introduced. The best crucibles for the purposes here contemplated are those made at Hesse, called *Hessian crucibles*. (Fig. 57.) These are so good and cheap that there is little inducement for substituting any other kind. Black-lead crucibles are much less frequently used, being more expensive, and not so generally applicable.

Hessian crucibles are commonly used in England, and are generally better than any others met with. Among those made in this country, the Cornish crucibles are the best, and some of these are, perhaps, not inferior to the Hessian.

[Besides Hessian crucibles, those of wedgwood-ware, plumbago, iron, silver, and platinum are used in certain operations of pharmaceutical chemistry. Wedgwood and Berlin-ware crucibles (fig. 58) withstand the alternations of temperature better when their exterior is luted. This is done with a mixture of soft fire clay and shreds of fine iron-turnings, which give it tenacity, a little gum-water being used at first. Black lead crucibles are best suited for metallurgic operations, where fusion at high temperatures is required. An iron crucible, good for some purposes, may be made from a mercury flask,—the top being removed, and the edge flared to a lip. The platinum crucible (fig.

59), so useful in analysis, should only be used with a charcoal or gas-furnace, as the sulphurous vapour of mineral coal destroys the exposed surface. They may be protected, by placing them within Hessian crucibles, with the intervening space filled with clay. The gas furnace, to be described hereafter, is well suited for all moderate ranges of temperature for this crucible, when urged by the bellows blowpipe.—W. P.]

It usually happens that the crucible is destroyed during the process, or rendered unfit for use on any subsequent occasion. This is especially the case when the substance operated upon undergoes fusion. When it remains unfused, in the state of powder, as is the case with the oxides of zinc, iron, and copper, &c., the same crucible may, with careful and judicious management, be made to serve for two or three operations.

The crucible ought not to be placed immediately on the grate or bars of the furnace, but on a stand provided for its reception. Stands, composed of the same materials as the crucibles, are made for this purpose, but, in the absence of such, a piece of brick, or an old crucible placed bottom upwards, may be used. When pieces of brick are used, as these are often to a certain extent fusible, and would in such case adhere to the bottom of the crucible, thus occasioning inconvenience on withdrawing it from the fire, it is desirable to guard against such result by putting a layer of sand or bone-ash between the crucible and its stand.

A little management is required in putting the crucible into the fire. It ought not to be exposed to a strong heat without previous preparation, for if it be too suddenly heated it will almost inevitably crack from unequal contraction. The cold crucible should, therefore, be gradually warmed by placing it on the top of the furnace, or in any suitable place for this purpose, previously to its introduction to the fire. The fracture of a crucible is sometimes caused by putting into it pieces of metal, which are intended to be fused, in such a way that, extending across the crucible from one side to the other, and fitting in tightly while cold, there is no room left for their expansion when heated.

Small crucibles, having a capacity equal to about four ounces, may, in most cases, be heated in any one of the laboratory furnaces that may be in use for other purposes. Indeed, crucibles of six or twelve ounces' capacity may often be heated in this way, or at least by the use of a small portable furnace. When the crucible has a capacity of a pound or more, it becomes necessary to use a furnace constructed

expressly for such operations. There are several kinds of furnace used for this purpose, but the *wind-furnace*, which is the oldest, is still generally preferred: it affords the means of efficiently heating crucibles of any size.

The air or wind-furnace.—This furnace should be constructed of the best fire-bricks, and it should be connected with a high chimney, so as to insure a good draught. The interior of the furnace may be made either square or round, each of these forms having its own peculiar advantages and defects. The round form is convenient for the reception of a crucible, and economical in the consumption of fuel, for the corners in the square furnace contribute little to the available heat when used for these operations; but it is not so easily constructed as the other, unless fire-bricks, shaped for the purpose, are employed, and these cannot always be obtained. There are some processes, however, in which the square furnace is more convenient than the round, and as the former of these is always more easily built than the other, and especially with bricks of the usual shape, preference is generally given to this form.

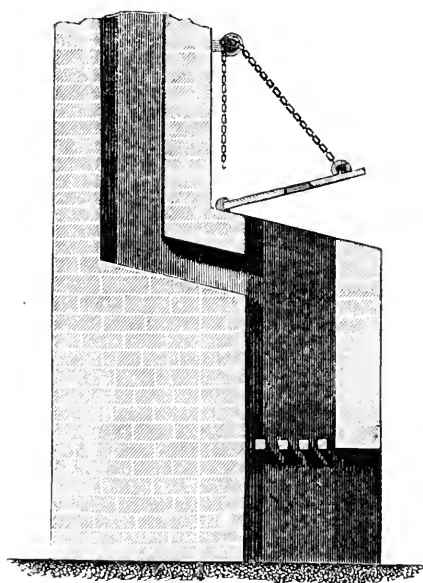
In erecting a wind-furnace, it is desirable to select a situation for it in which there is easy access to a suitable chimney without carrying the flue horizontally for any distance, or having any sharp angles that might impede the draught. It has been recommended, that this furnace should be built over an underground vault or cellar, so that by breaking through the arch of the vault a supply of air may be obtained from below for the fire. This plan, however, presents few advantages, and is subject to some objections. I prefer having the draught-hole of the furnace made in the floor of the laboratory, beneath and in front of the furnace, the part projecting beyond the furnace being covered with an iron grating through which the air is admitted.

The grate or bars of the furnace ought to be as near the floor as possible, so that the whole elevation should not be inconveniently high, and that the operator may be able to introduce or remove crucibles and other apparatus through the opening at the top. The draught-hole or ash-hole may be either on a level with the floor, as shown in figs. 60 and 61, or it may be immediately under the floor, as already mentioned, and projecting in front of the furnace, with a movable iron grating over it, which may be taken up to remove the ashes from beneath. The mouth of the furnace is covered with a cast-iron plate, coated on the inside with fire-clay to protect it from the action of the fire, and fixed as shown in the drawings. This plate

is raised and lowered by means of a chain passing over a pulley, when the crucible is introduced or removed, or fresh fuel is supplied to the fire. There is a small hole in the centre of the iron plate through which the progress of any operation which is going on in the furnace can be observed. Fig. 60 represents a vertical section, and fig. 61 a front view of this furnace with the cover partly raised.

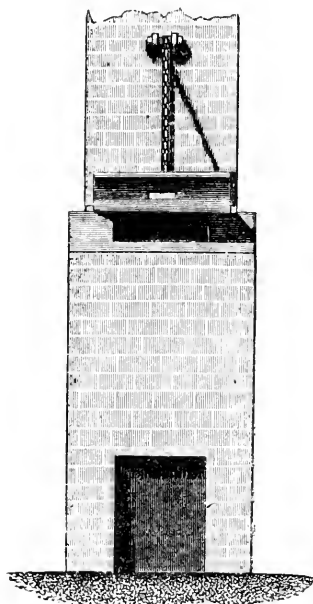
The furnace-bars are sometimes made of wrought, sometimes of cast-iron. The latter are certainly to be preferred, inasmuch as they are cheaper, and are made of a more suitable form than those of wrought-iron. They are now generally made much deeper and more massive than formerly; and when thus formed they possess the advantage of lasting much longer, and of improving the draught of

Fig. 60.



AIR-FURNACE.

Fig. 61.



AIR-FURNACE.

the furnace, by forming a good and efficient heating surface, in passing over which the air becomes warmed before coming into contact with the ignited fuel. It has been proved, in the process of smelting with the hot-blast, that the intensity of the heat produced by combustion is increased when the air supplied to the fuel is previously warmed.

The best form for furnace-bars is shown in figs. 62, 63, and 64.

Fig. 62 represents a lateral view of the bar; fig. 63 represents it as seen from above; and fig. 64 a transverse section through the middle of the bar, in the direction of the line *a b*. The ends are quadrangular, and the bar is wider here than in the intervening part, as shown in fig. 63, so that when the bars are placed with the ends close to each other, there is a suitable space left for the admission of air. The lower side of the bar forms an elliptical curve, and it is narrower on this side than at the top, as shown in figs. 62 and 64, this form being given to it to increase the draught, and to extend the heated surface over which the air has to pass.

This form of fire-bar, which is called *fish-bellied*, is found to be very advantageous. The heat of the strongest fires, which would melt bars of the old form, or so soften them that they would bend and become useless, produces little or no injurious effect upon these. The heat communicated from the burning fuel to the upper surface of the bar is rapidly distributed by conduction throughout the whole mass of metal, and as a current of air is at the same time passing in contact with this, the heat seldom becomes so much concentrated as to heat the lower side of the bars even to redness.

Fig. 62.

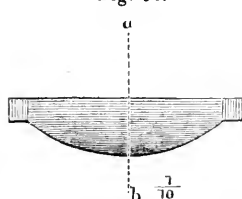


Fig. 63.



Fig. 64.



There is usually a square opening in the front wall of the wind-furnace, which is formed in building it, and then stopped up with bricks or a stone, which fits into it, so that it may be used, for any particular purpose, to allow the neck of a retort, or a tube, to pass through; but this is seldom required in strictly pharmaceutical processes.

The heated air and products of combustion of the furnace pass into the chimney through a rather contracted flue, which is called the *fox*. This contraction promotes a more complete combustion of gases, which otherwise would pass into the chimney without yielding the full amount of heat that they are capable of producing, and by the generation of which, the heat, and consequently the draught of the chimney, is increased. A sliding door, called a *damp*er, is sometimes fixed in this part of the flue, by which means the opening may be contracted or enlarged at pleasure.

In the air or wind-furnace, a strong draught and active combustion

are produced at the expense of much fuel, which is necessarily consumed in heating the chimney, so as to get the furnace into vigorous operation. It has been found from actual trial, that if the fuel used for this purpose were lighted under a boiler, and the steam generated applied to a steam-engine, the power thus produced would be capable of putting into motion with equal force ten or twelve times as much air as that which passes through the chimney of the wind-furnace. It is evident, therefore, that a great saving in expense might be effected by substituting steam, or some other power, for the means provided in the wind-furnace, in getting the required draught or current of air.

The operations in a pharmaceutical laboratory are not generally of sufficient extent to require the application of a steam-engine, but, in the absence of this, the power of the human arm, which is not otherwise put into requisition during the heating of a body in the furnace, might be applied to mechanical means for effecting a current of air.

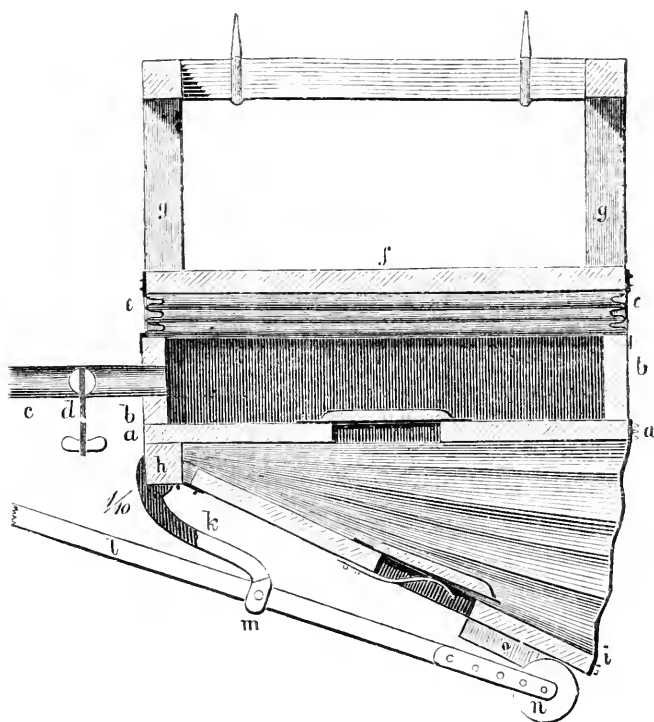
The *bellows* is the implement through which the power of the arm is generally applied in creating a draught for a furnace. By the use of this implement, time, fuel, and space, are economised. Time is gained, inasmuch as, by a few strong blasts, a draught may be created which, without this means, would only be attained after the fire had burned for some time. For the same reason, fuel would be economised; and as a tall chimney is not necessary when the draught is created by mechanical means, space might be economised, when this is a consideration, by substituting a small portable *blast-furnace* for the fixed and more bulky wind-furnace. I removed the wind-furnace from my laboratory ten years ago, and substituting a portable blast-furnace, which, when not in use, may be put into any unoccupied corner, have never experienced inconvenience from the change.

It has now to be considered what is the best construction for the *bellows* and the *blast-furnace*. The forge-bellows, as usually constructed, has certain defects, which, however, may be easily obviated. The wedge-form has probably been given to the common bellows from an erroneous notion that the air would more easily and forcibly enter the pipe when directed in this way, than would otherwise be the case; but this form is objectionable, and ought to be abandoned, such a geometrical shape being substituted as shall unite the greatest cubical contents with the smallest extent of lateral surface. Amongst the rectilinear figures, that which answers best to the required conditions will, in a transverse section of the bellows, represent a square.

When the board constituting the upper part of the bellows, or that to which the weight is attached, is fixed on one side by a hinge,

according to the usual construction, it will necessarily shift its position in reference to the horizon at every point through which it passes in rising and falling; and the pressure exerted by the weight will vary with all these alterations of position, being least available when the bellows is opened widest, from the weight being then thrown more on to the side fixed to the hinge, where it produces no effect, and increasing as the board becomes more nearly restored to the horizontal position. This loss, and constant variation of pressure, arising from one side of the movable top being fixed, is a great defect; it may be obviated by doing away with the hinge, and making the top to rise horizontally, the leather being attached on all sides in equal folds, as it is in the accordion and other similar instruments.

Fig. 65.



THE DOUBLE BELLOWS.

The double bellows consists of two chambers, into the lower of which the air is first drawn; and from this it is subsequently transferred through a valve into the upper chamber, which serves as a sort of regulator, by which the intermitting puffs of the single bellows are

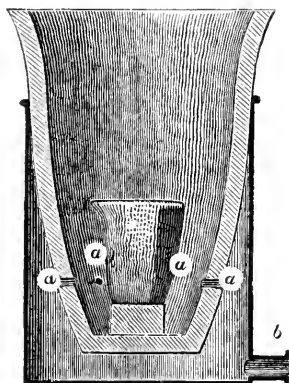
changed to a continuous and uniform current of air. The partition between the two chambers is permanently fixed to a firm framework, as shown at *g, g*, fig. 65, the frame being just large enough to admit of the bulging out of the leather during the working of the bellows. The fixed partition, with its valve, are represented at *a, a*, and immediately above this there are two boards (*b, b*), into one of which the air-pipe (*c*), with its turning valve (*d*), is inserted. The folded leather (*e, e*), which, when expanded, forms the upper chamber, is fixed to the boards (*b, b*) below, and above to the board (*f*), which forms the top of the bellows. The leather (*e, e*) of the upper chamber is shown in a state of collapse. The framework (*g, g*), as represented in the drawing, is intended to be fixed to the ceiling.

The lower, or supply chamber, is fixed at one end to a piece of wood (*h*), to which the bottom board (*i*), with its valve, is attached by hinges. The iron arm (*k*), is also attached to *h*, and this forms a stationary fulcrum (*m*) for the lever (*l*), by which the board (*i*) is raised. There is a small roller (*n*) at the end of the lever to lessen the friction, and this roller works in a groove formed by two pieces of wood, one of which is shown at *o*. A flat plate of cast-iron may be fixed on the board (*f*) to give the required pressure to the air.

The *furnaces* which are adapted for use in those cases where the draught is promoted by means of a bellows, have now to be described.

Crucible-Furnace.—The smallest furnace of this kind is such as may be made out of a large black-lead crucible. This furnace is represented in fig. 66. About three inches from the bottom of the crucible, four or six holes (*a, a, a, a*) are made with a gimlet, horizontally through its side. This is easily done with black-lead crucibles, in consequence of their soft texture, but those made of hard materials would not admit of it. The crucible, thus prepared, is encased by a cylinder made of sheet-iron, into which it fits tightly at the top, while from the tapering shape of the lower part of the crucible, a vacant space is left in the bottom of the cylinder, as shown in the drawing. There is a pipe (*b*) at the bottom of the cylinder, which is connected with the tube of the bellows, and a blast is thus directed into the vacant space in the

Fig. 66.



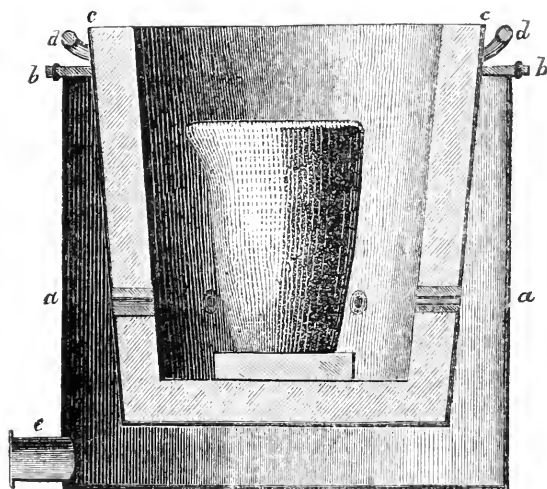
CRUCIBLE-FURNACE.

cylinder, from whence it passes through the holes *a, a, a, a*, to supply the combustion in the black-lead crucible.

I have a furnace of this kind in use, the cylinder of which is eight inches in diameter, and ten inches high. A crucible of twelve ounces' capacity may be brought to a full white-heat in this furnace, and when it has been kept in operation for some little time, the draught becomes really a hot-blast, from the air being in contact with the heated metal previous to its entering the fire. With a coke-fire the flame scarcely extends a foot above the fuel, but the heat and light are so intense that the eye cannot endure it, and neither crucible nor fuel are distinguishable. Care must be taken that the support for the crucible does not consist of any fusible material, such as common brick, for in such case it would inevitably adhere to it, and there would be danger of breaking the crucible in attempting to separate them.

Seftstroem's Furnaces.—These are constructed on the same principle as that last described, but they are made of any required size, and may therefore be used for those operations requiring a larger fire than the crucible-furnace admits of.

Fig. 67.



SEFTSTROEM'S FURNACE.

The outer case or cylinder (*a a*), fig. 67, is made of stout sheet-iron. It is somewhat contracted at the top by means of a ring (*b b*), which is riveted on, and into this ring a second cylinder (*c c*) fits, as shown in the drawing. The second cylinder is made of the same material as the first; it has two handles at *d d*, and is slightly conical,

so that, without being a permanent fixture, it fits tightly into the ring, being inserted up to the points at which the handles are attached, and it may be removed at any time to facilitate the clearing away of obstructions from the air-holes, or to remedy other defects.

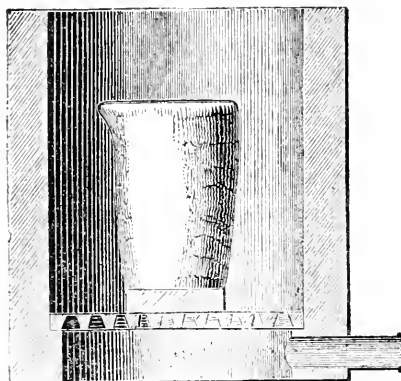
The inner cylinder has six or eight tubes, about half an inch in diameter, and two inches in length, fixed by means of rivets at equal distances from each other round its circumference, about five or six inches from the bottom, and projecting inwards. The inner surface of this cylinder is lined with fire-clay to the thickness of the projecting tubes, which, after carefully drying it by exposure to the air, and filling up any cracks that may be formed during this part of the process, is finally hardened by the heat of an operation such as the furnace is intended for. Before submitting it to a strong heat, it is important that the clay should be well dried spontaneously, and the clay mixture used should be such as will not contract much in drying. The best mixture for the purpose is made by incorporating old broken crucibles, or burnt clay, reduced to powder, with the moist and unburnt fire-clay (Stourbridge clay), adding as much of the former as can be introduced without destroying the adhesiveness of the resulting mass.

The outer cylinder has a tube (*e*) near the bottom, to which the pipe of the bellows is attached. During the action of the bellows the air is compressed in the space between the two cylinders, and is thus forced through the tubes into the fire contained in the inner cylinder. From the length of these tubes, and the conducting power of the iron of which they are made, the air thus entering the fire is previously well warmed, so as to assume the character of a hot-blast more completely than is the case with the *crucible-furnace* previously noticed. The air entering in separate horizontal currents from every side produces a most intense heat in this part of the furnace; and not only is this heat the strongest that a furnace can afford, but being of equal intensity on all sides, the crucibles exposed to it are less liable to crack than would otherwise be the case. The surface of the clay-coating of the furnace generally becomes glazed, from the action of the heat on the materials used in contact with the ashes of the fuel. Even Hessian crucibles sometimes collapse in the heat of this furnace. This intense heat is seldom or never required for pharmaceutical purposes, but lower degrees of heat may be obtained by regulating the supply of air.

If a piece of brick be used to form a stand for the crucible, it will be necessary to interpose a stratum of sand between it and the bottom of the crucible, to prevent them from adhering together.

Common Blast Furnace.—A furnace, the construction of which would be cheaper and easier than that of either of the foregoing, may be made by using a cylinder, similar to the outer cylinder of fig. 66, or fig. 67, and merely coating the inside of it with fire-clay, making a projection near the bottom for the reception of a set of fire-bars, on which the fire is to be placed, while the pipe for conveying the air enters immediately under this.

Fig. 68.



COMMON BLAST FURNACE.

Fire-bars, suitable for the purpose, may be obtained ready-made at any ironmonger's. A furnace of this kind is represented in fig. 68. It will be sufficiently powerful for most pharmaceutical purposes, and will occupy less space in proportion to its capacity than those represented in figs. 66 and 67.

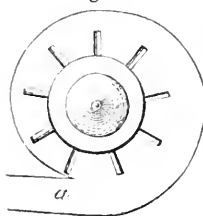
In using these furnaces, the fire should be first ignited with charcoal, and afterwards

supplied with coke, broken into small pieces about the size of a walnut.

It will be necessary to adopt some means for preserving the iron cylinders of these furnaces, or, at least, those parts of them that are exposed to the air, from being rapidly destroyed by rust, as they inevitably would be if put into a damp place without protection from the air. The difficulty of accomplishing this object, constitutes one of the greatest objections to this kind of furnace. There is no better method of protecting them than by coating the iron-work with coal-tar or solution of asphaltum, and renewing this from time to time as it is destroyed by the heat.

The Centrifugal Blower.—Instead of the double bellows, the centrifugal blower may be sometimes used with advantage, especially as it occupies less space, and, as usually constructed, is less expensive. It consists of a number of vanes or fanners, radiating from a horizontal shaft or axle, and enclosed within a cylindrical box. On the two opposite sides of the box, and immediately surrounding the axle of the fanners, open spaces are left for

Fig. 69.



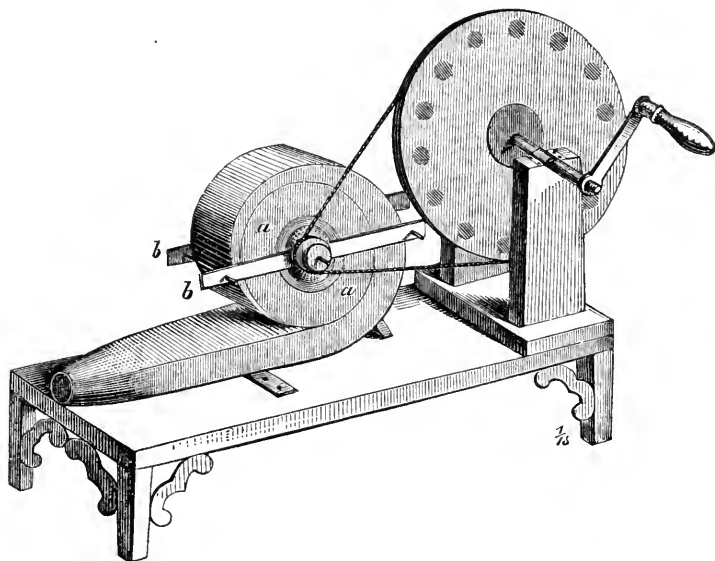
the entrance of the air, which, when put into motion by the rapid rotation of the fanners, is propelled by the centrifugal force through a tube attached to the circumference of the box. Fig. 69 represents a section of this part of the apparatus, showing the position of the fanners in the box, and the tube *a*, through which the air is discharged. It will be observed that the fanners nearly touch the circumference of the box at the point *a*, but at no other part, by which means a greater current of air is propelled into the tube. Fig. 70 represents a vertical section of the fanner, made in a direction at right angles with that of the section shown in fig. 69. The block of wood is here shown, attached to the end of the axle, on the outside of the box, on which the cord works which gives motion to the fanners.

Fig. 70.



The apparatus, complete, is represented in fig. 71, which is drawn to about the one-fifteenth or one-twentieth the real size of the apparatus, as usually employed. An apparatus similar in principle, is described in the Chapter on EVAPORATION.

Fig. 71.



THE CENTRIFUGAL BLOWER.

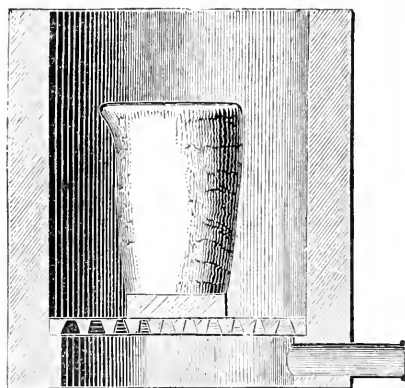
This blower will be found very convenient for sending a strong current of air through a portable furnace, as it may be used in any situa-

tion in which it may be most convenient to place the furnace; and when not in use it may be hung against the wall, or put into another apartment.

The kind of furnace represented in fig. 72, will be found to be that best suited for use with the centrifugal blower. The air-pipe of the furnace should be of pretty large dimensions, and the bars of the grate should be thick, and not too close together.

One great advantage in this means of forcing a current of air into a blast-furnace is, that when the apparatus is attached to the air-pipe

Fig. 72.



COMMON BLAST-FURNACE.

of the furnace, it occasions no obstruction to the free ingress of air while the blower itself is not in operation. In this respect it differs from the bellows, which, when not in action, stops all access of air to the bottom of the fire.

Flame-Furnace, or Reverberatory Furnace.—There are some operations in which it is found advantageous to expose the vessel to be heated to the action of the flame and hot air of the fire without being in contact with the

ignited fuel. Furnaces constructed for this purpose are sometimes called *flame-furnaces*. They are extensively used in chemical manufactories, but in these cases the substances operated upon are not generally contained in crucibles, but exposed on a horizontal bed of the furnace, over which the flame of the fire passes. The furnaces used in the manufacture of soda, and in the process of puddling iron, are of the kind here alluded to. When intended for pharmaceutical purposes, however, the construction is somewhat different from that adopted in the foregoing cases.

The fuel used in furnaces of this kind should be rich in hydrogen. Wood, peat, or brown coal, may be employed, but not charcoal or coke, because these latter do not burn with sufficient length of flame.

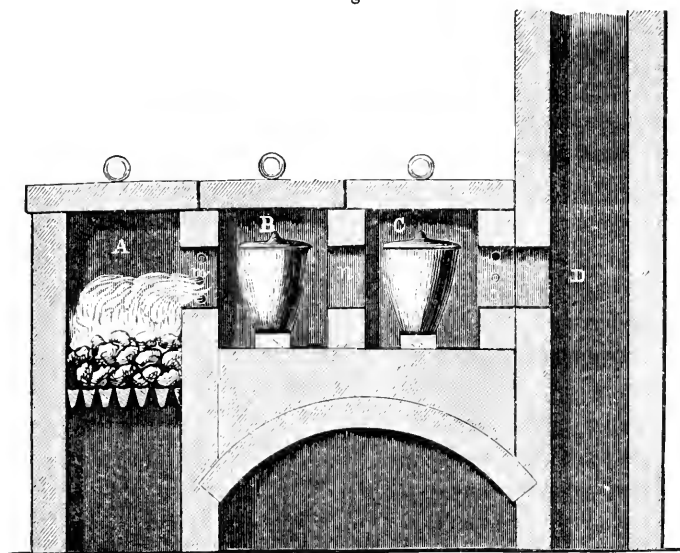
A flame-furnace has been erected in the laboratory at Giessen, where it has been found to answer remarkably well for the preparation of potassium. It possesses this great advantage, that the wrought-iron retort, employed in the process, not being in contact with the fuel, is not, as it otherwise would be, converted into the more fusible

cast-iron, by the absorption of carbon. The dry wood which is employed as fuel, is burnt in a separate fire-place, and the flame from this is conducted through a narrow channel into the chamber containing the wrought-iron vessel, where it plays upon the latter with an intensity of heat which may be compared to that of the flame of a large blow-pipe.

In the mint at Carlsruhe, these furnaces are used for melting the various metals in crucibles, two or more of which are submitted to different degrees of heat, according as their proximity to the fire is greater or less.

Fig. 73 represents one of these furnaces constructed for the recep-

Fig. 73.

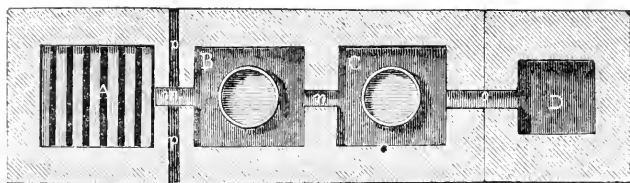


FLAME-FURNACE.

tion of two crucibles. In the space A the fuel is burnt, which must consist of dry wood, peat, or good coals. The flame passes through the narrow shaft (*m*), where it mixes with atmospheric air, which is admitted here through several small holes placed as shown in the drawing, and which are also further represented at *p p* in fig. 74.

By opening or closing these holes, the supply of atmospheric oxygen may be regulated so as to prevent any deposition of carbon, and to produce the greatest degree of heat. The flame, after playing round the crucible in the space B, passes through the contracted channel (*n*) into the second space C, where it again expands and envelopes the

Fig. 74.

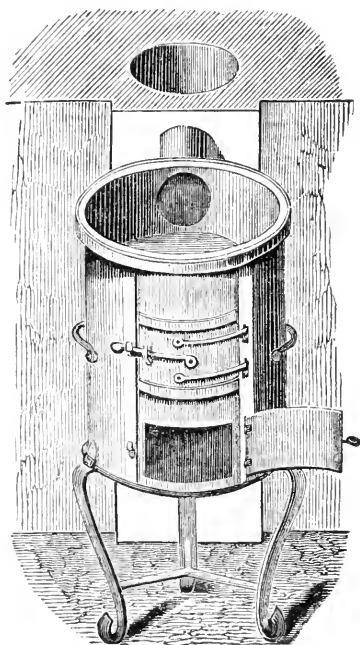


crucible placed there, and finally escapes into the chimney (D). The flame and heat are often sufficient to admit of heating even a third crucible, when provision is made for that number.

These furnaces offer a great facility for the removal and reintroduction of crucibles, as these operations do not at all interfere with the fire. In ordinary cases, when the crucible is surrounded by the fuel, on removing the former, the fuel falls into its place, and interferes with the convenient introduction of another crucible. It is also advantageous to have a graduated heat to which the crucibles can be successively introduced.

These furnaces should be built with the best fire-bricks, cemented together with fire-clay. The circular air-holes *p, p*, are made by inserting round bars of iron in the brickwork, and afterwards pulling these out before the cement has hardened.

Fig. 75.



COMMON PORTABLE FURNACE.

Common Portable Furnaces.—In some cases a common portable furnace may be made to serve a great many useful purposes, even superseding, in very small establishments, the necessity for more costly and bulky apparatus. Fig. 75, represents a furnace of this kind. It is intended to be placed against a chimney, into which the flue is inserted. Fig. 76, is a vertical section made through the fire-place, and fig. 77, a horizontal section.

Vessels of the form represented in fig. 78, may be used for boiling any liquids over this furnace.

Distillation is best effected by substituting a sand-pot for the boiler, and placing a retort in the sand.

There should also be an iron cover for the top of the furnace, to be put on when neither of the other vessels is required, and this cover should consist of two or more rings with a central piece, as shown at C, fig. 4, page 21, so that, by removing one or more of these, an opening of greater or lesser magnitude may be effected here, which would be found convenient in conducting crucible operations.

Fig. 76.

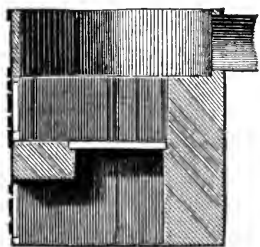


Fig. 77.

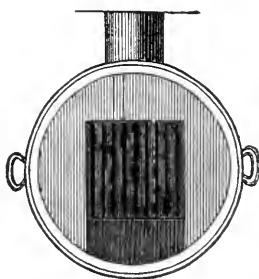
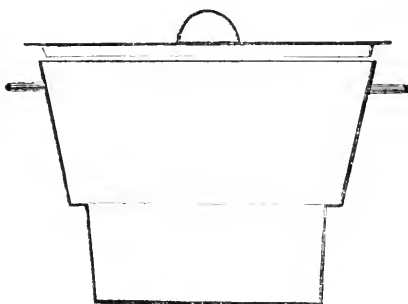


Fig. 78.



There is another *common portable furnace* which it may be well to describe. It is used without a chimney, and charcoal is, therefore, the only fuel that can be conveniently burnt in it, but it possesses this advantage, that it may be placed in any part of the laboratory, and moved about at pleasure. Figs. 79 and 80 represent this furnace. Fig. 79 is a vertical section, showing the position of the grate, which is fixed at the bottom of a larger, and immediately over a smaller, cylinder, both of which are made of sheet-iron. The upper cylinder, which forms the fire-place, should be lined with clay. It is furnished with a small door through which fresh fuel may be introduced when the top is covered with any apparatus. The lower cylinder, which forms the channel through which air is supplied to the fire, extends nearly to the ground. At its lower extremity it is riveted

to a tripod stand as shown in fig. 80, from the three extremities of which rods of iron extend upwards to the larger cylinder, so as to give to it greater firmness and stability. At the bottom of the smaller cylinder there is a sliding-door, shown in fig. 79, by opening or shutting which the supply of air to the fire is regulated. The ashes fall through the lower cylinder, and are received on to a tray (A, fig. 80) in front of the door. The air having to pass over the hot ashes, and through the cylinder, which acquires heat by conduction, enters the fire at a temperature well suited for active combustion.

Fig. 79.

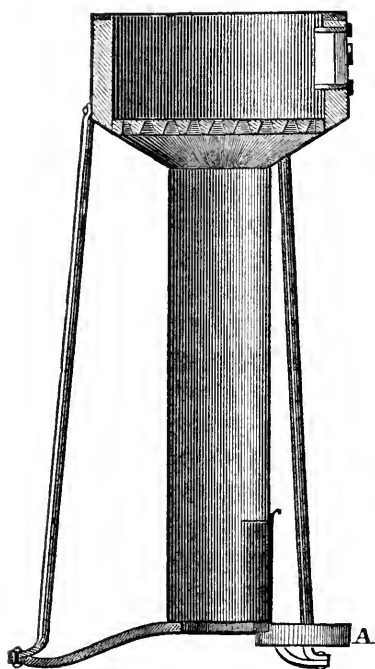
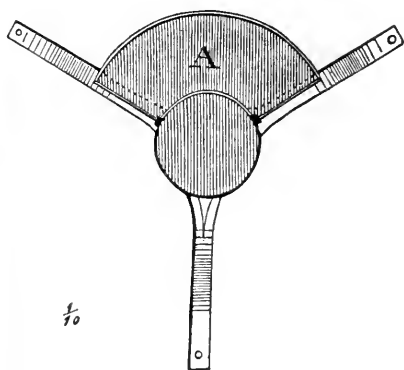


Fig. 80.

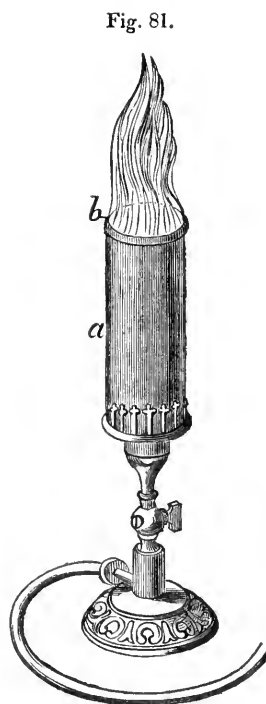


COMMON PORTABLE FURNACE.

This furnace is applicable to a great number of processes where only a moderate heat is required.

[*Gas and Alcohol Lamps.*—In the greater number of dispensing establishments the range of operations requiring heat is very limited, and the space for operating confined chiefly to the shop. To these the possession of gas, and alcohol lamps, is invaluable. Where gas is to be had, gas-burners should be used in preference to all other lamps, as safer, more economical, and far more conveniently managed.

Gas has long been used for heating purposes, but its smokiness was a serious objection to its use until the suggestion of Dr. Duncan, of Edinburgh, was carried into practice. This consists in burning it after admixture with atmospheric air. A wire gauze is stretched across the top of a tinned iron cylinder, into which, at its lower and open end, the gas enters from a jet and mixes with the air as it rises. The mixture is ignited above the gauze and burns with a clear bluish flame. Fig. 81 shows the manner in which this is effected.



The original cylinder of Sir A. Robinson was thirty inches long, but it has been found that six or eight inches is quite long enough; and if several diaphragms of coarser wire gauze be placed at intervals in the cylinder, its length may be decreased to four inches; especially if the gas issues into the cylinder from such a burner as fig. 82.

The gas-furnace of Mr. Rickets, noticed in Chap. I., is equal to a charcoal fire for many of the purposes of the pharmacist, and can be conveniently arranged at the working counter. A set of the shorter cylinders, from one to four inches in diameter, should be at command—made of tinned iron—one end covered with fine brass wire gauze, simply crimped over the edge, and a piece of copper wire twisted around it. When no means of protection are used, the gauze requires to be renewed, if constantly in use, at intervals of one or two months; especially if corrosive substances are allowed to come in contact with it from the boiling over of liquids. It may be protected by having a short cylindrical cap, covered with coarse iron wire gauze, slipped over the end of the cylinder, and the space between the two wire tissues filled with granular pumice-stone, free from dust.—W. P.]

The following arrangements are adopted in the laboratory of the Pharmaceutical Society, where they were originally introduced.

Gas-Burners.—The gas-burner generally used is that represented in fig. 82. It consists of a perforated ring (a) the diameter of which

is two inches and three quarters; this is supported on a foot (*b*), and attached by a flexible tube to the gas-pipe, so that it may be moved to any part of the work-table, to suit the arrangement of other apparatus.

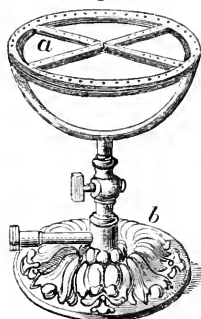
Fig. 83, represents a larger gas-burner, the diameter of which is six inches, but this is rarely required excepting in some particular cases, in which it may be wished to have the heat diffused over a large surface. The smaller burner affords heat enough to boil a gallon or more of water in a metallic vessel.

Fig. 82.



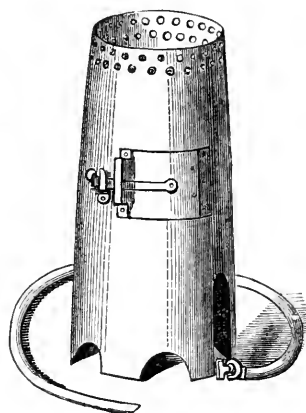
GAS-BURNER.

Fig. 83.



GAS-BURNER.

Fig. 84.



GAS-FURNACE.

Gas-Furnaces.—The gas-furnace (fig. 84) is used to confine the heat of the flame from the gas-burner, to protect it from being blown about by currents of air, and at the same time to form a support for the vessel containing the liquid to be heated. This furnace consists of a slightly conical cylinder of sheet iron, which is covered with black japan varnish to protect it from becoming corroded with rust. It is four and a half inches in diameter at top, five and a half inches in diameter at the bottom, and ten inches in height. The air for supporting the combustion of the lamp, is admitted through apertures at the bottom of the cylinder, while the hot air and products of combustion, escape through a number of small holes near the top. There is a door on one side of the furnace, which is used for lighting the lamp when any apparatus is fixed over the opening above; there is also an aperture extending from the bottom upwards to the height of about five inches, through which the flexible gas tube passes, and which admits of the lamp being placed on a block of wood, so as to bring the flame nearer to the top of the furnace when this is desired.

If the apparatus to be heated be large, or the gas-burner (fig. 83)

be employed, it will be necessary to use a furnace of larger dimensions than that described. In these cases the cylinder should be seven inches in diameter, and twelve inches in height; and with a cylinder of this size it is unnecessary to have it larger at the bottom than at the top.

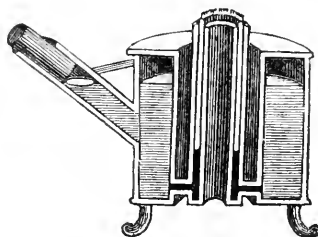
Retorts, flasks, or dishes, may be heated over these furnaces, and the operator, by regulating the supply of gas, will have complete control over the amount of heat applied.

The *mixed gas furnace*, (figs. 1, 2,) which is described at page 20, does not afford complete control over the intensity of the heat, and therefore is not generally applicable for the purpose contemplated. It gives a strong heat and is perfectly free from smoke, but the size of the flame cannot be regulated at pleasure, as the flame of the gas-burner (fig. 82) can. The air being allowed free ingress at the bottom of the tube (A. fig. 1), requires the admixture of a constant quantity of gas issuing from the tube (B), to form a combustible mixture which shall burn at the mouth of the tube. If the supply of gas be much diminished, the mixture ceases to be combustible, and the flame is extinguished. This defect might be remedied, by providing means for regulating the supply of atmospheric air, as well as of gas, but such addition would render the apparatus more complicated and expensive. The furnace (fig. 84) with the gas-burner (fig. 82) will, therefore, be found to answer better in those processes where it is desirable to have complete control over the amount of heat applied.

[The objection to the gauze burner, above stated, is only real when the amount of heat is reduced below ten per cent. of that capable of being communicated by the burner, and it rarely happens that a greater reduction is required in the same process. Besides, when the short cylinders are used, the reduction may be yet greater.

As gas can only be profitably employed by the pharmacist in those cities and towns where it is introduced for the purposes of illumination, a substitute is best found in alcohol and oil lamps. Alcohol lamps, from their superior cleanliness, and easy management, are to be preferred to those for oil. Where a strong heat is desired the lamp of Dr. Mitchell (fig. 85) is to be preferred. It is an Argand burner, placed in the centre of a cylindrical reservoir, with which it communicates at bottom by several

Fig. 85.

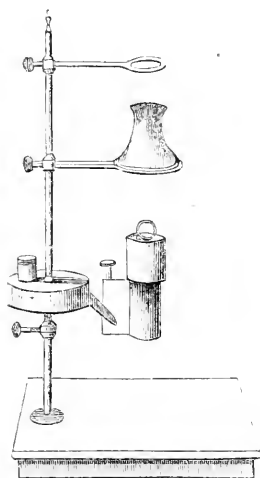


DR. MITCHELL'S LAMP.

small tubes. The alcohol is introduced by the lateral tube, which also serves for a handle, and is closed with a cork. A common Argand wick is slipped into the burner, which is raised or lowered by a pair of sharp-pointed forceps. A small orifice is made at the top of the reservoir, for the admission of air as the alcohol is consumed. The construction of the handle allows it to be used as a lip in pouring out the alcohol, after the operation is finished, or a tin cap may be placed over the burner to prevent the evaporation of the alcohol, if it is left in the lamp.

Fig. 86 represents the improved alcohol-lamp of Berzelius. The

Fig. 86.



BERZELIUS'S LAMP.

Fig. 87.



LAMP CHIMNEY.

reservoir passes over the upright wire of the lamp-stand, and it communicates with the Argand burner by a tube. The wick is raised when required by the screw at the side of the burner.

The power of Dr. Mitchell's lamp may be greatly increased, by having two concentric burners, one three inches and the other an inch and a half in diameter. Oil may be used in these lamps, but its smokiness is an objection. Whatever fuel may be used, chimneys (fig. 87) should be placed on the lamp, so that a steady heat shall be conducted upwards, and the flame not be influenced by lateral currents.

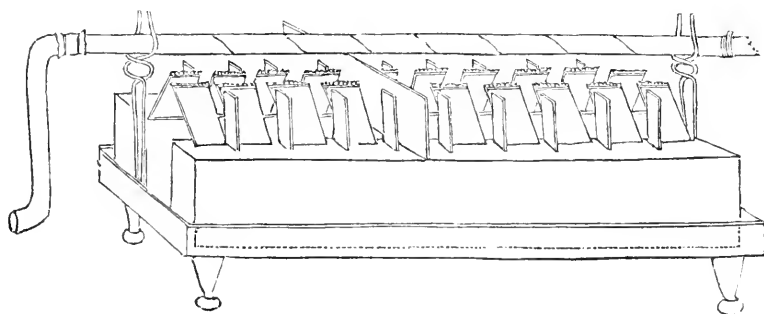
The common glass spirit-lamp, with a glass cap, (fig. 88,) is exceedingly useful in the shop for sealing, and some blowpipe operations, and is always ready for use. Such a lamp may be easily constructed from a wide-mouthed vial, with a piece of glass, or tin tube passing through the cork.

The lamp for igniting a length of tube, invented by Mr. Cooper, and described by Faraday, is represented at fig. 89. "It consists of a frame, ten or eleven inches long, which being raised upon four feet, has an aperture from end to end of 0·8 or 0·9, of an inch in width. It is furnished at each end with a wire support, adjustable in its height, and bent at the top into a convenient form for retaining a tube in a horizontal position. The lamps are two in number, and stand on the frame, one on each side of

Fig. 88.



Fig. 89.

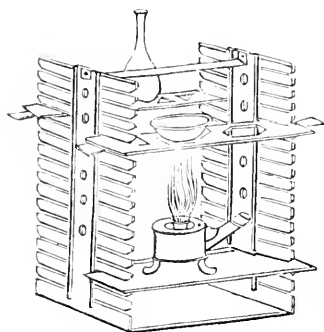


COOPER'S LAMP-FURNACE.

the aperture. They have each ten burners, passing obliquely upwards from one edge, and inclining towards those of the other lamp, over the aperture mentioned. Each burner is 0·8 of an inch in length, half an inch wide, and about that distance apart from its neighbours, and the lamps may be put so near to each other as to leave the two sets but little asunder, or they may be removed to a greater distance. Small up-rights are fixed on the top of the lamp between the burners; there is also a feed-pipe on each lamp, closed by a cork; and each burner is furnished with a cap to cover it, and prevent the evaporation of the alcohol when the lamp is not in use. The whole of this apparatus is made of tin-plate and iron wire."

The wicks for this lamp are common cylindrical wicks introduced double. Dr. Mitchell believes that this lamp may be greatly improved by having the burners arranged as in his lamp, fig. 85, each rising vertically from the space between the lamps, and connected with the reservoir of alcohol, by a tube at its base. Dr. Mitchell has also suggested an arrangement, fig. 90, under the name of a "retort-stand," which

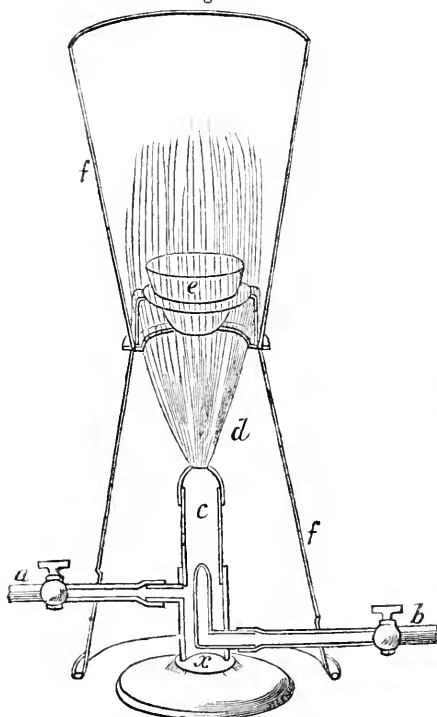
Fig. 90.



MITCHELL'S RETORT-STAND.

removed along with the shelf, either for examination, agitation, or any other purpose." (*Faraday's Chem. Manip. Amer. Edit.*)

Fig. 91.

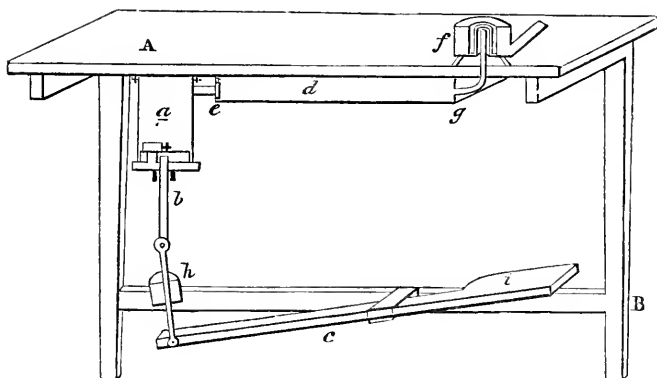


Blowpipes. — The gas blowpipe of Mr. Redwood, fig. 91, which is described in the chapter on miscellaneous operations, is an admirable arrangement for obtaining a powerful heat in small operations, as for heating a platinum or small wedgwood crucible, and in tube operations requiring reduction, sublimation, &c. The jet (*b*) may be applied to the lamp of Dr. Mitchell, or a common cylindrical gas-burner.

The syringe blowpipe, (fig. 92 exhibits a section,) is a very simple and complete arrangement for obtaining a strong blast for this purpose. It consists of a brass cylinder *a*, attached firmly to the under side of the table, A, B.

b is the piston, with a valve opening upwards; *c* a treadle connected with the piston-rod; *h* is a weight to cause the descent of the piston; *d* a tinned iron reservoir for the condensed air; *e* a tube con-

Fig. 92.



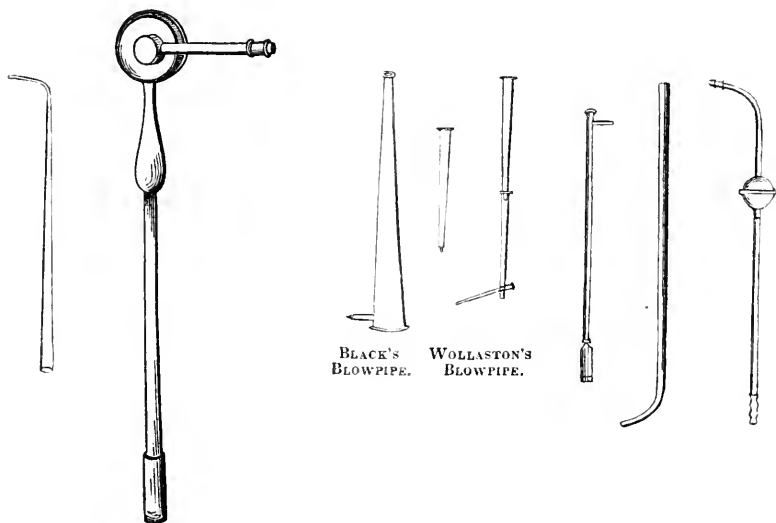
necting the reservoir with the cylinder, and closed by a valve opening inward; *f* a Mitchell's lamp; *g* a tube and jet connected with the reservoir. In using the blowpipe, the foot is placed at *i*, which depresses the treadle and forces the contents of the cylinder into *d*, the weight *h* causes the descent of the piston when the foot is raised, when a second portion of air is forced in; the air in the reservoir is soon sufficiently condensed to keep up a steady current, of great force, through the jet *g*.

Fig. 93.

Fig. 94.

Fig. 95.

Fig. 96.



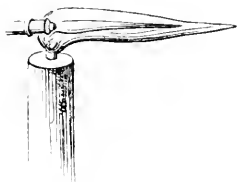
Every pharmacist should be familiar with the use of the common mouth-blowpipe. There are numerous cases where he is called upon to use it, either in testing, or in adapting tube apparatus. A variety

of forms has been given to this instrument by different chemists. In its simplest form, (fig. 93), it is a conical tube, terminating in a minute orifice or jet, which is curved so that the air issues at right angles with the axis of the tube. Some have a globular enlargement, (fig. 96), which serves as a reservoir for the condensed air, and retains the saliva that passes in with the breath. Fig. 94 represents the blowpipe of Mr. Pepys. Figs. 95, 96, exhibit other forms of the mouth-blowpipe as suggested by Dr. Black, Dr. Wollaston, and others. The chief merit of Dr. Wollaston's instrument is, that it may be taken to pieces, and the parts slipped into each other so as to reduce it to a size suitable for convenient carriage in the pocket.

In using the blowpipe, the object to be attained is a constant and uniform blast of air through the tube. In order to effect this, the operator must use the muscles of his cheeks as the sides of a bellows, the mouth being replenished with air from the lungs, as occasion demands; and their action must be so regulated that the lungs will keep up the current, during the time required to fill the mouth with air. During the period that elapses, while the contents of the mouth are being expelled, the lungs are inflated through the nostrils. This process is easily acquired by a little patience, and by practice can be continued, with little fatigue, for ten or fifteen minutes.

The flame of a lamp or candle, (fig. 97,) urged by a blowpipe, is a miniature blast-furnace, and the jet of flame possesses the same qualities that a furnace does. The interior, where the carbon of the fuel is not wholly oxidized, is possessed of reducing or deoxidizing power, whilst the extreme point is powerfully oxidizing, a fact readily proven by the reduction of the oxide of lead on the surface of flint glass, when

Fig. 97.



held in the interior of the flame, whilst it is again oxidized by being held in the terminal portion.

THERMOMETERS.

The thermometer generally used in the United States and England, is that of Fahrenheit, whilst the continental chemists and pharmacutists, use chiefly the Centigrade thermometer, and that of Reaumur. The Centigrade, owing to its decimal graduation, is to be preferred to the others for scientific purposes; but as habit has established

the use of Fahrenheit's scale with us, the following table, which has been copied from "Noad's Chemical Manipulation and Analysis," presents a convenient means for converting the degrees of these scales into each other at a glance.

In Fahrenheit's instrument, the range between the freezing and boiling points of water is 180° , the zero being 32° below the freezing point; hence, on this scale the congeling of water takes place at 32° , and it boils at 212° .

In the Centigrade scale, the freezing point is the zero, and the point of ebullition 100° ; each degree being equal to 1.8 of Fahrenheit's.

Reaumur's scale has these two points 80° apart, the eightieth degree being the boiling point of water. This thermometer was formerly much more used than at present, in France, the Centigrade having replaced it.

To reduce Centigrade degrees to those of Fahrenheit.

Rule: Multiply by 9 and divide by 5, and add 32.

To reduce Fahrenheit's degrees to those of Centigrade.

Rule: Subtract 32, multiply by 5, and divide by 9.

To reduce Reaumur's degrees to those of Fahrenheit's.

Rule: Multiply by 9, divide by 4, and add 32.

To reduce Fahrenheit's degrees to those of Reaumur's.

Rule: Subtract 32, multiply by 4, and divide by 9.

TABLE

FOR THE CONVERSION OF DEGREES ON THE CENTIGRADE THERMOMETER
INTO DEGREES OF FAHRENHEIT'S SCALE.

Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
—50	—58·0	—10	14·0	30	86·0	70	158·0	110	230·0
—49	—56·2	— 9	15·8	31	87·8	71	159·8	111	231·8
—48	—54·4	— 8	17·6	32	89·6	72	161·6	112	233·6
—47	—52·6	— 7	19·4	33	91·4	73	163·4	113	235·4
—46	—50·8	— 6	21·2	34	93·2	74	165·2	114	237·2
—45	—49·0	— 5	23·0	35	95·0	75	167·0	115	239·0
—44	—47·2	— 4	24·8	36	95·8	76	168·8	116	240·8
—43	—45·4	— 3	26·6	37	98·6	77	170·6	117	242·6
—42	—43·6	— 2	28·4	38	100·4	78	172·4	118	244·4
—41	—41·8	— 1	30·2	39	102·2	79	174·2	119	246·2
—40	—40·0	0	32·0	40	104·0	80	176·0	120	248·0
—39	—38·2	+ 1	33·8	41	105·8	81	177·8	121	249·8
—38	—36·4	2	35·6	42	107·6	82	179·6	122	251·6
—37	—34·6	3	37·4	43	109·4	83	181·4	123	253·4
—36	—32·8	4	39·2	44	111·2	84	183·2	124	255·2
—35	—30·0	5	41·0	45	113·0	85	185·0	125	257·0
—34	—29·2	6	42·8	46	114·8	86	186·8	126	258·8
—33	—27·4	7	44·6	47	116·6	87	188·6	127	260·6
—32	—25·6	8	46·4	48	118·4	88	190·4	128	262·4
—31	—23·8	9	48·2	49	120·2	89	192·2	129	264·2
—30	—22·0	10	50·0	50	122·0	90	194·0	130	266·0
—29	—20·2	11	51·8	51	123·8	91	195·8	131	267·8
—28	—18·4	12	53·6	52	125·6	92	197·6	132	269·6
—27	—16·6	13	55·4	53	127·4	93	199·4	133	271·4
—26	—14·8	14	57·2	54	129·2	94	201·2	134	273·2
—25	—13·0	15	59·0	55	131·0	95	203·0	135	275·0
—24	—11·2	16	60·8	56	132·8	96	204·8	136	276·8
—23	— 9·4	17	62·6	57	134·6	97	206·6	137	278·6
—22	— 7·6	18	64·4	58	136·4	98	208·4	138	280·4
—21	— 5·8	19	66·2	59	138·2	99	210·2	139	282·2
—20	— 4·0	20	68·0	60	140·0	100	212·0	140	284·0
—19	— 2·2	21	69·8	61	141·8	101	213·8	141	285·8
—18	— 0·4	22	71·6	62	143·6	102	215·6	142	287·6
—17	+ 1·4	23	73·4	63	145·4	103	217·4	143	289·4
—16	3·2	24	75·2	64	147·2	104	219·2	144	291·2
—15	5·0	25	77·0	65	149·0	105	221·0	145	293·0
—14	6·8	26	78·8	66	150·8	106	222·8	146	294·8
—13	8·6	27	80·6	67	152·6	107	224·6	147	296·6
—12	10·4	28	82·4	68	154·4	108	226·4	148	298·4
—11	12·2	29	84·2	69	156·2	109	228·2	149	300·2

TABLE.—CONTINUED.

Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
150	302.0	185	365.0	220	428.0	255	491.0	290	554.0
151	303.8	186	366.8	221	429.8	256	492.8	291	555.8
152	305.6	187	368.6	222	431.6	257	494.6	292	557.6
153	307.4	188	370.4	223	433.4	258	496.4	293	559.4
154	309.2	189	372.2	224	435.2	259	498.2	294	561.2
155	311.0	190	374.0	225	437.0	260	500.0	295	563.0
156	312.8	191	375.8	226	438.8	261	501.8	296	564.8
157	314.6	192	377.6	227	440.6	262	503.6	297	566.6
158	316.4	193	379.4	228	442.4	263	505.4	298	568.4
159	318.2	194	381.2	229	444.2	264	507.2	299	570.2
160	320.0	195	383.0	230	446.0	265	509.0	300	572.0
161	321.8	196	384.8	231	447.8	266	510.8	301	573.8
162	323.6	197	386.6	232	449.6	267	512.6	302	575.6
163	325.4	198	388.4	233	451.4	268	514.4	303	577.4
164	327.2	199	390.2	234	453.2	269	516.2	304	579.2
165	329.0	200	392.0	235	455.0	270	518.0	305	581.0
166	330.8	201	393.8	236	456.8	271	519.8	306	582.8
167	332.6	202	395.6	237	458.6	272	521.6	307	584.6
168	334.4	203	397.4	238	460.4	273	523.4	308	586.4
169	336.2	204	399.2	239	462.2	274	525.2	309	588.2
170	338.0	205	401.0	240	464.0	275	527.0	310	590.0
171	339.8	206	402.8	241	465.8	276	528.8	311	591.8
172	341.6	207	404.6	242	467.6	277	530.6	312	593.6
173	343.4	208	406.4	243	469.4	278	532.4	313	595.4
174	345.2	209	408.2	244	471.2	279	534.2	314	597.2
175	347.0	210	410.0	245	473.0	280	536.0	315	599.0
176	348.8	211	411.8	246	474.8	281	537.8	316	600.8
177	350.6	212	413.6	247	476.6	282	539.6	317	602.6
178	352.4	213	415.4	248	478.4	283	541.4	318	604.4
179	354.2	214	417.2	249	480.2	284	543.2	319	606.2
180	356.0	215	419.0	250	482.0	285	545.0	320	608.0
181	357.8	216	420.8	251	483.8	286	546.8		
182	359.6	217	422.6	252	485.6	287	548.6		
183	361.4	218	424.4	253	487.4	288	550.4		
184	363.2	219	426.2	254	489.2	289	552.2		

Every pharmacist should be provided with at least one thermometer for use in the laboratory. This should be graduated from 30° to 40° below the zero of Fahrenheit, to 630° above it; and it is as well to have the Centigrade scale parallel on the opposite side of the tube for the sake of convenience. The box-wood upon which the scales are engraved, should be in two pieces, connected on the back

by a hinge, that the lower end of the scale, to the fiftieth degree, may be turned back against the upper part, so as to expose the lower end of the tube and the bulb, for the convenience of dipping it in liquids whose temperature it is desired to ascertain. Such instruments may be had of the thermometer-makers.

Thermometers are sometimes constructed with the tube passing through a larger tube containing the scale, in such a manner as to float like a hydrometer, in the liquid to be examined. They are used by the sugar-boilers, and in the concentration of saline solutions, on a large scale, to ascertain the crystallizing point.

When the heat of an evaporating liquid is to be regulated by a thermometer, the instrument should be suspended in the liquid, and not suffered to rest on the bottom in contact with the vessel.

EFFECTS OF TEMPERATURE.

					Degrees below zero.
Greatest artificial cold produced by the evaporation of a mixture					
of solid carbonic acid and ether, <i>in vacuo</i> , by Faraday					- 160
Strongest nitric acid freezes	-	-	-	-	55
Sulphuric ether congeals	-	-	-	-	47
Liquid ammonia freezes	-	-	-	-	46
Mercury freezes	-	-	-	-	39
Proof spirit and brandy freeze	-	-	-	-	7
					Degrees above zero.
Oil of turpentine freezes	-	-	-	-	16
Strong wines freeze	-	-	-	-	20
Oils of bergamot and cinnamon	-	-	-	-	23
Vinegar freezes	-	-	-	-	28
Milk freezes	-	-	-	-	30
Ice melts	-	-	-	-	32
Olive oil freezes	-	-	-	-	36
Glacial acetic acid solidifies	-	-	-	-	36
Oil of aniseed freezes	-	-	-	-	64
Lard melts	-	-	-	-	from 90 to 97
Phosphorus melts	-	-	-	-	99
Stearine from hogs' lard melts	-	-	-	-	109
Spermaceti melts	-	-	-	-	112
Tallow melts (Thomson)	-	-	-	-	92

Gray's Supplement.—W. P.]

CHAPTER IV.

ON STEAM HEATING APPARATUS, AND ITS APPLICATIONS TO THE PURPOSES OF PHARMACY.

THE introduction of steam as a means of communicating heat in pharmaceutical processes, has caused a complete revolution in the general arrangements of the laboratory. Where efficient steam apparatus is introduced, the necessity for other means of heating, by the use of furnaces, is almost entirely superseded. But the full extent of the convenience and advantage of the employment of steam can only be fully appreciated in those cases where the daily work of the laboratory is such as to keep the apparatus in constant use.

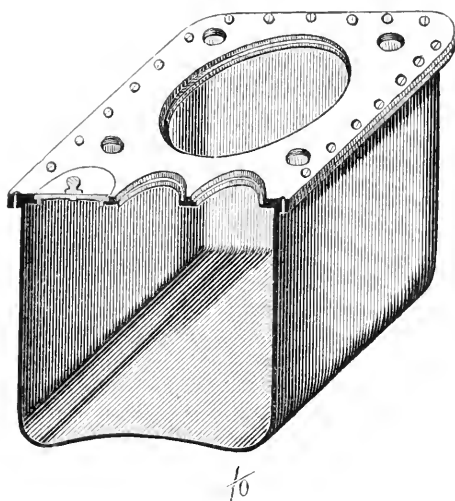
Several efforts have from time to time been made, especially on the continent, to contrive a steam apparatus that should be applicable to small pharmaceutical laboratories; but none has appeared to have given so much general satisfaction as that for which we are indebted to the late John Beindorf, of Frankfort. This apparatus is used throughout Germany and other parts of the continent, where it is distinguished by the name of *Beindorf's apparatus*, and in many cases *the apparatus*.

Beindorf himself, previous to his death, which occurred in 1833, had supplied the apparatus to a great many persons, and was in the habit of making them of two different sizes. The manufacture of them is still continued by his widow, who now conducts the business: but other manufacturers have adopted the form, or at least the principle, of the original apparatus, and they are now, therefore, made in many of the large towns.

The following description of the apparatus, including improvements or alterations introduced by himself, applies to that of the smaller size.

The boiler, fig. 98, is 18 inches long, $13\frac{3}{4}$ inches wide, and 13 inches deep. It is made of copper, the edges to the ends and bottom being somewhat truncated, and the bottom itself slightly arched, as

Fig. 98.



BOILER OF BEINDORF APPARATUS.

shown in the drawing. The sides are perpendicular, and have a flat flange or shoulder, to which the top is either soldered or screwed.

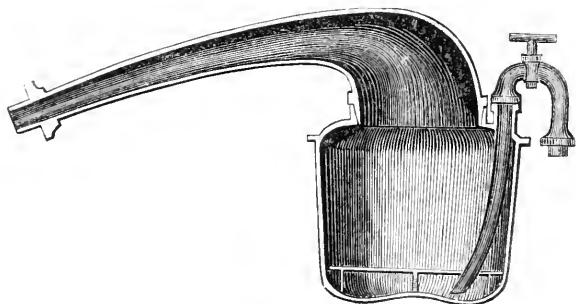
In the top there are four large circular openings,—one 11 inches in diameter, intended to receive the still and the evaporating vessels; two of $3\frac{1}{2}$ inches, and one of 3 inches diameter, for receiving vessels for maceration, &c.; there are also four small openings for attaching steam-pipes. The top has been made, sometimes of copper with rings of tin surrounding the openings; sometimes of polished iron or steel, with brass mountings; but I prefer having the top cast entirely of brass.

Fig. 98, represents a perspective view of the boiler cut transversely across three of the openings to show the interior.

The following vessels and apparatus are used with the boiler in different operations:—

1. *The cucurbit and head* (fig. 99) for distillation. This fits into the large opening in the top of the boiler, and the steam-pipe, repre-

Fig. 99.



CUCURBIT AND HEAD.

Fig. 100.



PERFORATED FALSE-BOTTOM.

sented in the drawing, is fixed to one of the small openings of the boiler, and carries steam to the bottom of the cucurbit, to be discharged underneath a perforated false bottom, which is separately shown in fig. 100.

2. *A tin dish or pan* for evaporating extracts or neutral solutions.

3. *A porcelain or Wedgwood-ware dish*, for solutions that would act on the tin, mounted with a ring of tin fitting into the opening in the boiler.

4. *A deep copper pan*, (fig. 101,) which dips into the boiler as far as the rim by which it is fitted to the opening. This is sometimes made larger and more shallow, with an external jacket, as represented in fig. 102: in this case the pan stands above the boiler, and the steam

Fig. 101.

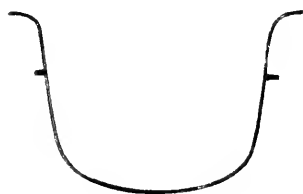
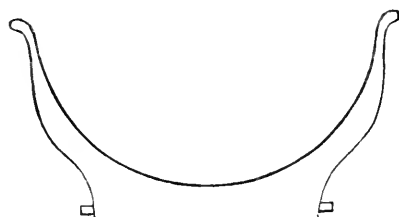


Fig. 102.

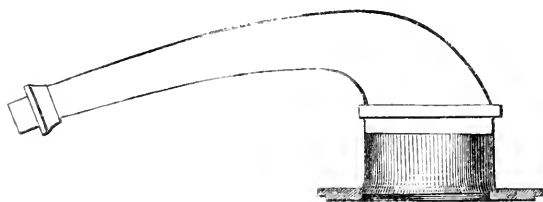


EVAPORATING PANS.

surrounds it in the space enclosed by the jacket. These are used for larger quantities of extract, for making lead plaster, &c.

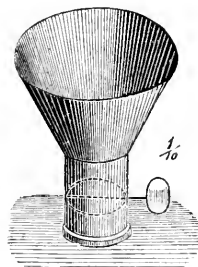
5. *A set of brass rings* fitting one within the other, with a circular piece in the centre, the whole forming a lid or cover for the large opening of the boiler. These are intended for contracting the size of the opening, so as to suit any dish or vessel of smaller diameter. The two largest of these rings with the still-head fitted in the centre, as used for distilling water without the cucurbit, are shown in fig. 103.

Fig. 103.



STILL-HEAD.

Fig. 104.



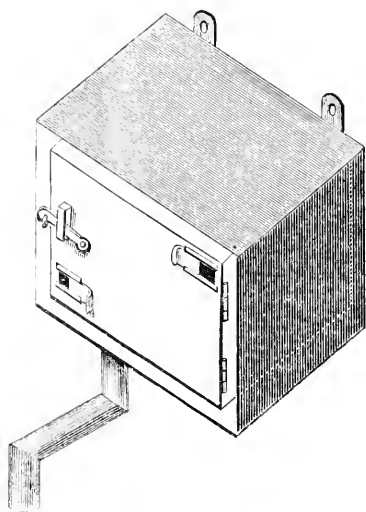
STEAM-FUNNEL.

6. *A funnel-shaped apparatus* (fig. 104). It is full eight inches in diameter at the top or mouth of the funnel, and the lower end or neck is made to fit into one of the second-sized openings in the boiler. In

the neck of this funnel-shaped appendage there is a valve formed of a disk of metal, across the diameter of which a wire is fixed, so that it may be turned to prevent or admit the admission of steam into the funnel. This appendage to the boiler is of great and frequent use; it affords a ready means of adapting retorts, dishes, and other vessels, of different sizes, so as to expose them to the heat of the steam.

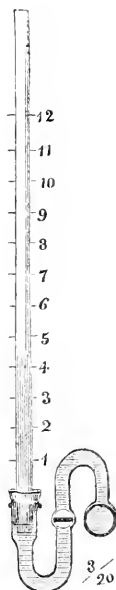
7. *A small hot-air chamber, made of zinc or other suitable metal*

Fig. 105.



HOT-AIR CHAMBER.

Fig. 106.



(fig. 105). This is a double or jacketted box, with a door in one side, and a tube for conveying steam from the boiler to the space enclosed by the jacket. There are two openings at the opposite corners of the door, furnished with sliding shutters, by which air is allowed to pass through when required. This box or chamber may be attached to a wall contiguous to the apparatus.

If an elevated rim be fixed round the top of the box, this may be filled with sand, so as to form a small sand-bath for processes in which little heat is required.

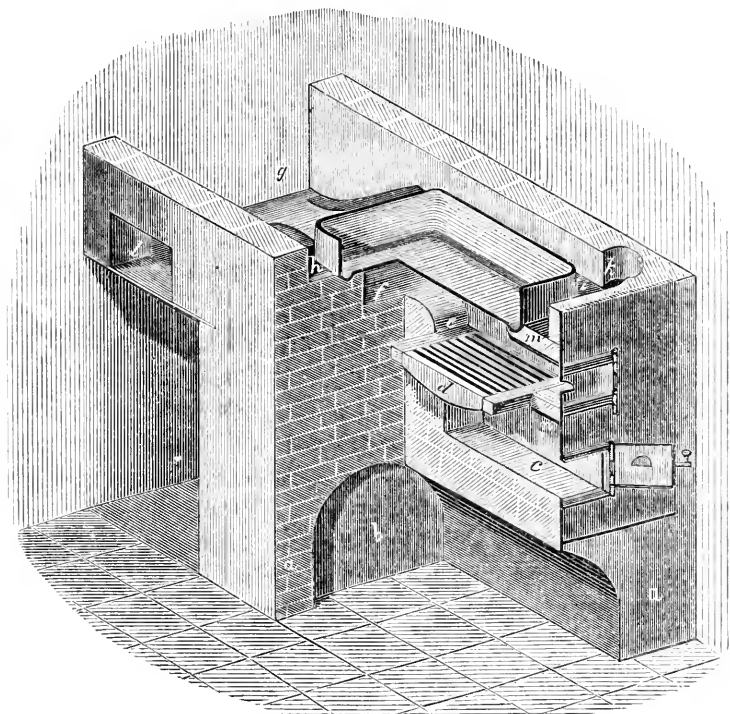
The Beindorf apparatus is not calculated for sending a strong jet of steam through pipes, as the least opposing pressure would cause the escape of the steam through the imperfect joints by which the several appendages are fitted into the top of the boiler.

An indicator of the height of the water in the boiler is a very

necessary part of the apparatus. That which I have found to answer the purpose best consists of a glass tube fixed to a bent brass pipe, which is attached to the cock by which water is drawn from the boiler. This is shown in the drawing (fig. 113), and the tube itself is more minutely represented by fig. 106. A scale of inches is fixed to the glass tube, which thus indicates the depth of the water in the boiler. There is a stop-cock in the bent brass pipe, by which the communication between the boiler and the glass tube can at any time be shut off, in case of any accident to the latter.

We have now to describe the construction of the stove or furnace by which the boiler is heated. The first question is, what will be the proper or most convenient height for the top of the boiler? It is necessary to have it so high that, in conducting the process of distillation, there shall be sufficient space, between the beak of the still-head

Fig. 107.

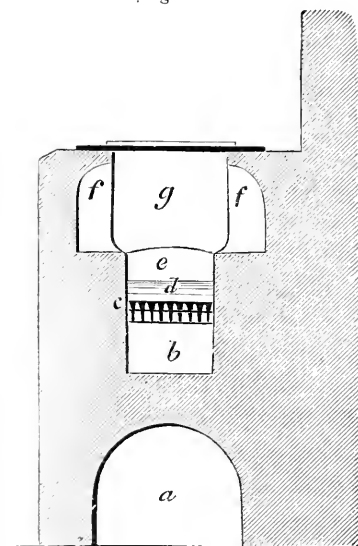


BEINDORF APPARATUS.

and the ground, for the worm-tub or refrigerator and the receiver below it. A pit or hole in the ground is sometimes provided for the latter to stand in, but this is subject to several objections, and ought, therefore, to be avoided, if possible.

Allowing 27 inches for the height of the worm-tub, and 14 inches for that of the stand on which it is placed, it would be found that 43 inches would be sufficient height for the top of the boiler, and this would not be too high to admit of the various required operations being conveniently conducted on it. If the apparatus be fixed at this height, there will be found to be sufficient space to have an arched receptacle for keeping the fuel in underneath the ash-pit. Fig. 107, represents the apparatus laid open so as to show the manner in which it is arranged and put together. The walls *a a* are first erected and arched over with bricks or covered with an iron plate. The end *b* is closed with brickwork. The top of the arch is now made level, and bricked up to the proper height for the bottom of the ash-pit door, which, as well as the fire-place door, is fixed to a cast-iron plate forming the front of the stove. The ash-pit extends the whole depth of the grate *d*. Immediately behind the grate rises the arched fire-bridge *e*, a portion of which is shown in the drawing. Beyond this is the opening *f*, by which the fire passes off, which is commonly called the *fox*. The boiler rests with its edges all round on the brickwork, excepting at the *fox*. The

Fig. 108.



SECTION OF BEINDORF'S APPARATUS.

- | | |
|---------------------------------|--|
| a. The receptacle for the fuel. | e. The fox-hole. |
| b. The ash-pit. | f, f. The two flues passing along the sides of the boiler. |
| c. The grate. | g. The boiler. |
| d. The fire-bridge. | |

fire passing through the fox-hole and underneath the sand-bath, returns by two channels *h* and *i* along the sides of the boiler to the chimney-flue *k*. At *l* there is an opening, stopped with a loose stone or brick, for cleaning out the space underneath the sand-bath.

It will be found advantageous to have the front, in which are the furnace and ash-pit doors, entirely covered by a cast-iron plate. The doors should be 8 inches wide by $5\frac{1}{4}$ inches high. Twelve inches will be found to be a good length for the furnace bars.

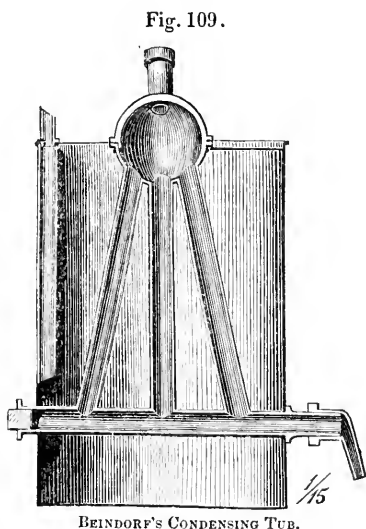
Fig. 108 represents a transverse section of the apparatus.

The *Sand-bath*, consists of a strong piece of sheet iron, with a rim turned up on every side, about $1\frac{1}{2}$ inch deep. It will be of the full width of the furnace, and may be

about fifteen or twenty inches in length. This is nearly filled with coarse, but properly sifted and clean, river sand. The sand should be passed through two sieves,—one for removing the dust and fine particles,—the other for separating small stones and coarse impurities. When properly purified by thus treating and washing it, the sand will not adhere to any vessels that may be placed in it. This sand-bath will be found to be very useful for a variety of purposes.

The cooling or condensing tub, should stand close to the apparatus, the distance being suited to the length of the neck of the still-head. The tub should always be kept filled with water, and ready for use. I would recommend that the pipes of the condenser should be rubbed over on the outside with a mixture of tallow and black lead, to prevent the adhesion of carbonate of lime, which is often deposited in considerable quantity from the water contained in the tub.

Beindorf's cooling or condensing tub, is represented by fig. 109, where a vertical section of it is shown. All parts of this condenser may be easily cleaned, which is not the case with the common worm-tub. Where there is only one condenser used, it is quite indispensable that it should admit of being perfectly cleaned, otherwise the product of each process will be contaminated with some part of that which preceded it.

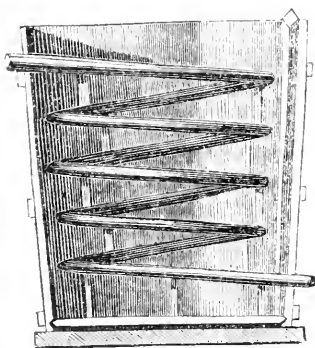


The common worm-tub, is shown in fig. 110. The worm is made of tin pipe and too much care cannot be taken to insure the purity of the metal employed in this, in common with all other metallic condensers. The principal objection to the common worm-tub arises from the difficulty there is in properly cleaning out the pipe. The means sometimes adopted for this purpose consists in letting a leaden ball, attached to a string, run through the worm, then fastening a sponge or bottle-brush to one end of the string and drawing it through, at the same time pouring some water in. If there be many coils to the worm, however, this method will be found impracticable, and the only available means will be to close the lower end of the pipe, then fill it with a solution of caustic alkali, and allow this to remain in for

some hours, then, having removed this and the condensing water from the tub, to pass a strong jet of steam through the worm for some time.

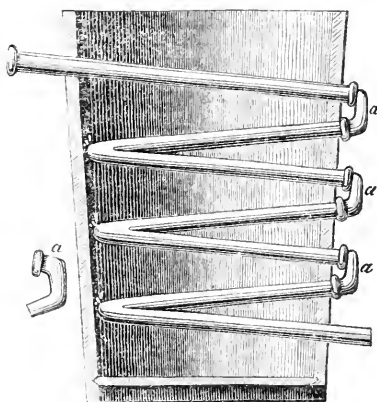
Another form of condenser has been proposed by Kolle. This is represented by fig. 111. The pipe is not bent circularly as that of the common worm is, but in the form of a zigzag, running to and fro in

Fig. 110.



COMMON WORM-TUB.

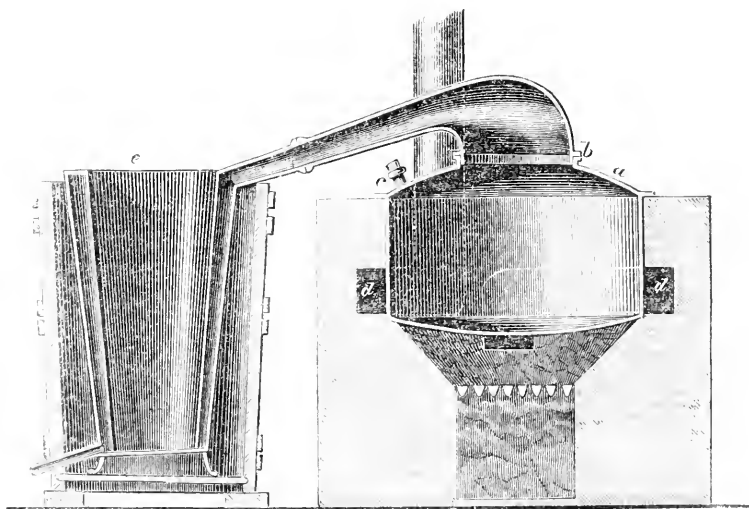
Fig. 111.



KOLLE'S CONDENSER.

a vertical plane. On removing the pieces of bent tube *a* the whole of the interior of the pipe may be cleaned by means of a stick or long

Fig. 112.



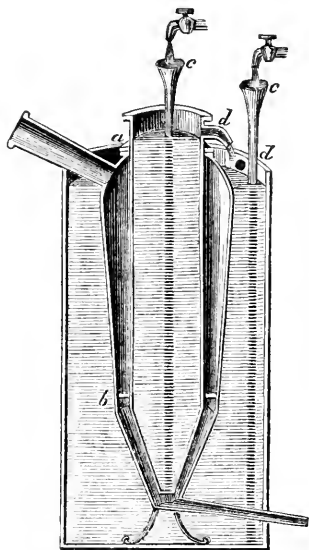
GADDA'S CONDENSER AND STILL.

brush. There is, however, a difficulty in keeping so many joints

water-tight, especially when the tub is made of wood, for the joints can only in such case be stopped with cement. If the tub be made of zinc or copper, the projecting ends of the tube may be soldered to it, and the liability to leakage entirely removed.

Gadda's Condensing Apparatus, is represented in fig. 112. It consists of two conical vessels of metal, of unequal size, the smaller being fixed within the other, and the space between them closed at the top and bottom. These are placed in a tub filled with cold water, which comes in contact with the inner and outer surface of the cones, while the space between is occupied by the vapour to be condensed. The drawing also represents a common still set in brickwork, showing the construction of the fireplace and flues. Gadda's condenser is subject to the objection which applies to the common worm, that it cannot be easily and efficiently cleaned out. To obviate this objection, Mitscherlich has given to it another form, which is represented in fig. 113. In this the inner part of the cone is made cylindrical, and may be taken out, so as to admit of the interior of the apparatus being cleaned. The inner and outer pieces of the cone are united at the top by a joint *a*. There is also a perforated ring *b* near the bottom, which keeps the inner cylinder in its proper place. Cold water is supplied by two jets, *c, c*, and the heated water is carried off by the pipes *d, d*. In using this apparatus it is necessary to have a constant supply of cold water, which can be drawn from a reservoir situated above the condenser, unless the tub containing the condenser be itself large enough to hold the required quantity of water.

Fig. 113.



MITSCHERLICH'S CONDENSER.

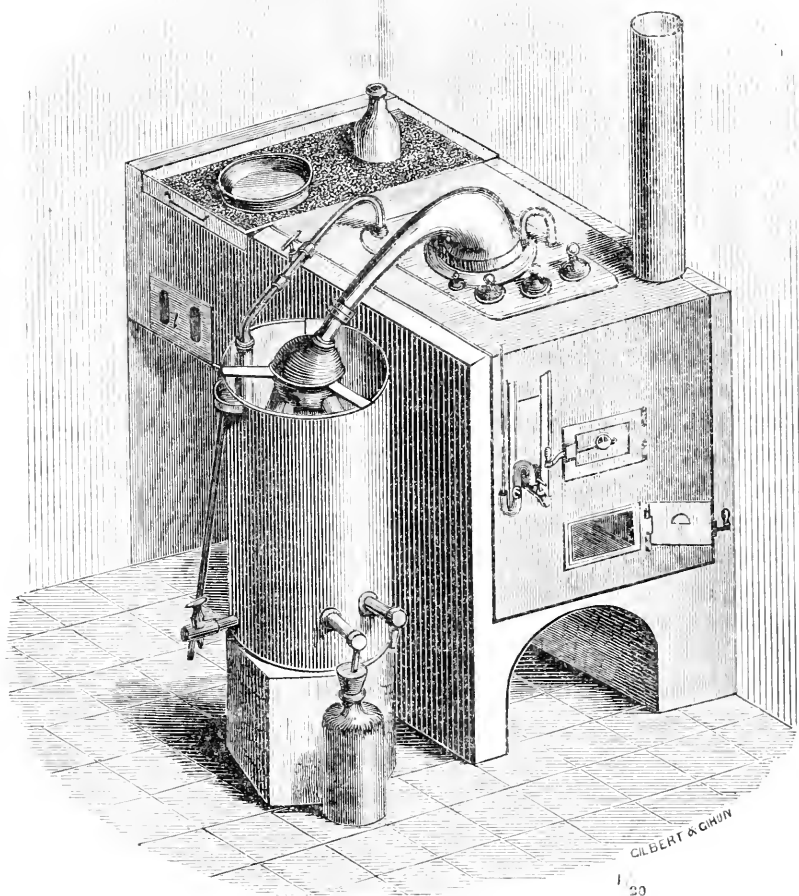
Fig. 114 represents the Beindorf apparatus and condenser in operation.

A brief description will now be given of the method of using the apparatus for the several purposes to which it is applicable.

DISTILLATION.—In the pharmaceutical laboratory, distillation generally has reference to the preparation of distilled waters. For this purpose the boiler is charged with rather more water than usual, so

that two or three gallons may be distilled without recharging it. The cucurbit (fig. 99) is then fitted into its place in the top of the boiler, and the steam-pipe being fixed as represented, and the herbs, flowers, &c., to be operated upon, put over the perforated false bottom of the cucurbit, the distillation is conducted by causing a jet of steam to pass

Fig. 114.



BEINDORF APPARATUS.

through and become charged with the volatile constituents of the solid ingredients. If essential oils be substituted for the vegetable substances which yield them, the former may be dropped on to bibulous paper, and this placed on the false bottom of the cucurbit. This mode

of operating is certainly subject to one objection, that the attachments of the several parts of the apparatus being loose, any obstruction to the free passage of the steam causes it to escape at the joints; and such an obstruction is sometimes occasioned by the condensation of steam in the cucurbit and the accumulation of water there so as to cover the end of the steam-pipe.

To obviate this difficulty, without the necessity of having recourse to a common still, I have had the still-head made to fit on to the opening in the boiler, by means of movable rings, as shown in fig. 103. The boiler itself is thus converted into a still, and the substances to be operated upon are put in with the water and distilled in the usual way. There are some cases in which this, which is the old method of distilling, answers better than that which consists in passing steam through the materials to be operated upon, contained in a separate vessel. Thus, for instance, in rectifying oil of turpentine, it is found that the oil passes over more rapidly when it is put into the still with the water, than is the case when steam is passed through the turpentine contained in a separate vessel. In the former instance, *small* bubbles of steam being generated in every part of the boiling water pass through and become charged with the turpentine which floats on the surface; while in the latter, *large* bubbles of steam being discharged from the steam-pipe in one place, the diffusion of the vapour of turpentine into this is less complete. By the former process, the products of the distillation will consist of about equal volumes of oil and water, while by the latter process there would be a much larger proportion of water. A similar result also occurs in distilling the oil from Copaiba. Again, in the distillation of bitter almond water, it is necessary to introduce the almond cake into the still with the water, as these must be allowed to digest together at a gentle heat for several hours before commencing the distillation.

This method of converting the boiler into a still is certainly subject to the inconvenience of its becoming contaminated with some of the substances operated upon, which may communicate a disagreeable taste or smell to the water afterwards, and it is, therefore, necessary to adopt some efficient means of cleansing the boiler after such operations.

Alcohol, and spirits generally, may be distilled by putting them into the alembic immersed in the water of the boiler, the heat communicated in this way being sufficient for the purpose. In distilling small quantities of spirituous or ethereal liquids, a retort put into the funnel-shaped apparatus fig. 104, as shown in fig. 115, may be used. Fig. 116 represents

the condenser which I am accustomed to employ for these volatile liquids. It consists of a glass tube *a*, one inch in diameter and thirty-

Fig. 115.

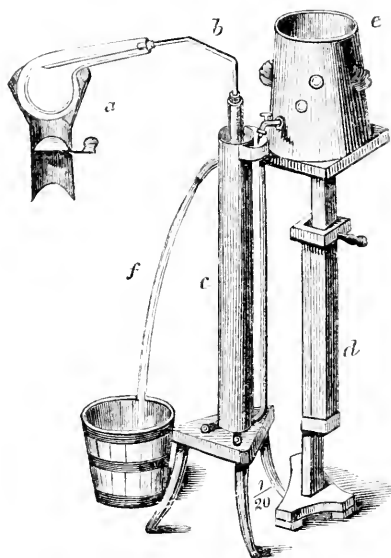
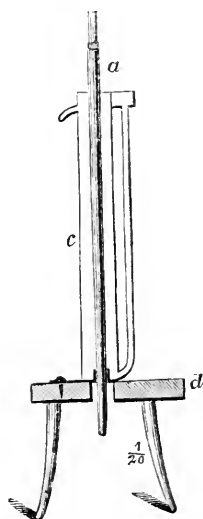


Fig. 116.



DISTILLATION OF SPIRITS.

eight inches in length, which is fitted by means of two perforated corks into the brass cylinder *c*, of four inches diameter, and about thirty inches in length. There is a small tube, as shown in the drawing, for conveying a stream of cold water to the bottom, and another near the top for carrying off the heated water. This apparatus is fixed vertically to a stool *d*, under which the receiver is placed.

In fig. 115 this apparatus is represented in operation. *a*, the retort placed in the funnel, with the bent tube *b* connecting it with the condenser *c*, in the manner recommended by Liebig. The object of this arrangement is to prevent condensation within the conducting tube, which passes some distance into the retort, and to cause none but the most volatile vapours to pass the highest angle of the tube. *e* is the tub for holding the supply of cold water which runs in a continuous stream through the condenser.

DIGESTION AND INFUSION.—In making some infusions, such as *Infusum Lini compositum*, and generally in the process of digestion in the sense in which that term is usually employed, the continued application of heat is required; and this is conveniently effected by the

Beindorf apparatus, the intermediate sized openings in the boiler being intended to receive vessels for this purpose.

SOLUTION, LIQUEFACTION, SAPONIFICATION, &c.—The solution of salts, of gum, of extracts, the liquefaction of fats, ointments, and plasters, and other processes of this description, are performed in round-bottomed vessels of tin, copper, or Wedgwood-ware, placed over one of the openings in the boiler. Lead plaster may also be made in the large pan by the heat of the boiler, and by conducting the process in this way, the liability of spoiling the product by the application of too strong a heat, which is always incurred when the ingredients are heated over the naked fire, is entirely avoided. But the time required for effecting the complete saponification of the oil by the water-bath heat, is much more than it would be if a stronger heat were applied, two or three days being occupied in the former case to complete what might be made in little more than as many hours in the latter.

VAPORIZATION.—This process is of very frequent occurrence in the pharmaceutical laboratory. Extracts, solutions of salts, purified honey, and a variety of other substances, require in the course of their preparation, to be deprived of a part of their water. There are two ways in which this is effected: first, by generating steam at the bottom of the vessel, and throughout the liquid, which is called *ebullition* or *boiling*, and secondly, by generating steam only from the surface of the liquid, which is sometimes distinguished as *evaporation* or *surface evaporation*. By the former process the concentration is effected most rapidly, but it is subject to some objections. In the first place there is a greater dissipation and loss of any aromatic or volatile constituents that the liquid may originally have contained, than would occur from surface evaporation. There is also a danger of decomposing or burning any organic matter that may be present, and the liability to this increases as the inspissation proceeds. Extracts made in this way, if incautiously inspissated, frequently become to a great extent insoluble in water; whereas, had they been otherwise prepared, they would have been entirely, or almost entirely, soluble.

As the Beindorf apparatus will not admit of the steam being exposed to more than a very slight pressure, it will never attain a temperature sufficient to cause the ebullition of an aqueous liquor contained in one of the evaporating pans; for even should the steam in the boiler be a few degrees above the boiling point, the obstruction to the free transmission of the heat in its passage through the metal pan, and still more if the pan be of earthenware, will cause the contents of the pan to be four or five degrees lower.

Surface evaporation, however, as it takes place at a temperature below the boiling point of the liquid, may be effected with this apparatus in either of the pans, figs. 101 and 102. This kind of evaporation depends upon the diffusion of the vapour into the superincumbent air, and therefore the rapidity of the evaporation is greatly increased by maintaining a constant change of atmosphere, that which is charged with vapour being replaced by dry air into which diffusion can take place freely. Indeed, if the liquid were contained in a close or covered vessel, such as a still, evaporation from the surface would not proceed at all after the air in the still had become charged with vapour, unless some mechanical means were adopted by which a change or current of air may be effected through the vessel. It is also desirable, with the view of promoting this kind of evaporation, that as large a surface as possible of the liquid should be exposed to the air, and that this should be constantly changed so as rapidly to substitute the warmer particles from below for those which have been cooled by the influence of evaporation.

In the inspissation of extracts and other similar preparations, and especially where this is effected by surface evaporation, it is necessary to keep the substance constantly agitated by stirring it. The process of stirring not only causes a new surface, and a more extended surface to be exposed to the air, but at the same time it occasions a change of atmosphere in contact with the liquid.

But how is this very essential, yet tedious and insignificant process of stirring, to be effected? If, as is usually the case, it be done by manual labour, the whole time of an assistant will be occupied in doing that which one of his fingers could accomplish; while at the same time from the very tediousness and insignificance of the work, it is often neglected.

THE STIRRER.—Having experienced these inconveniences, I have provided a remedy for them, by constructing a mechanical stirrer. This is a machine which, when wound up, will keep the contents of a pan continually, and regularly stirred for about three hours, without any personal attention. Fig. 119 represents this apparatus. It consists of three spindles or pivots set in an iron frame. The first, or principal pivot, *a*, fig. 119, carries a wooden barrel two inches and a quarter in diameter, and four inches and a half long. At the front or outer end, there is a projecting rim to prevent the cord from slipping off, and to occasion the return of the coil. This pivot passes through the frame, and carries at the end a double winch *k, k*, the handles of which are of unequal distance from the spindle, so as to admit of the

coil being wound up by a quicker or slower motion. The double winch also serves to balance one handle against the other, and prevent any irregularity in the motion of the machine when in action. At the opposite end of the spindle there is a toothed wheel *b*, and immediately beyond it another *c*. The wheel *b* is provided with a click, as shown in fig. 117, so that if it be turned in the direction indicated by the

Fig. 117.

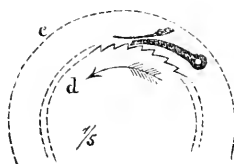


Fig. 118.

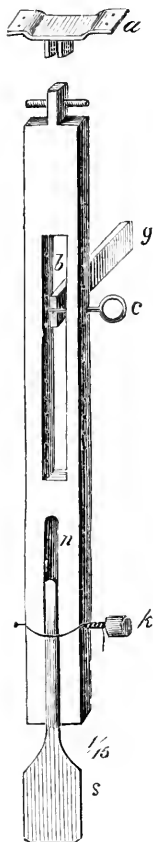
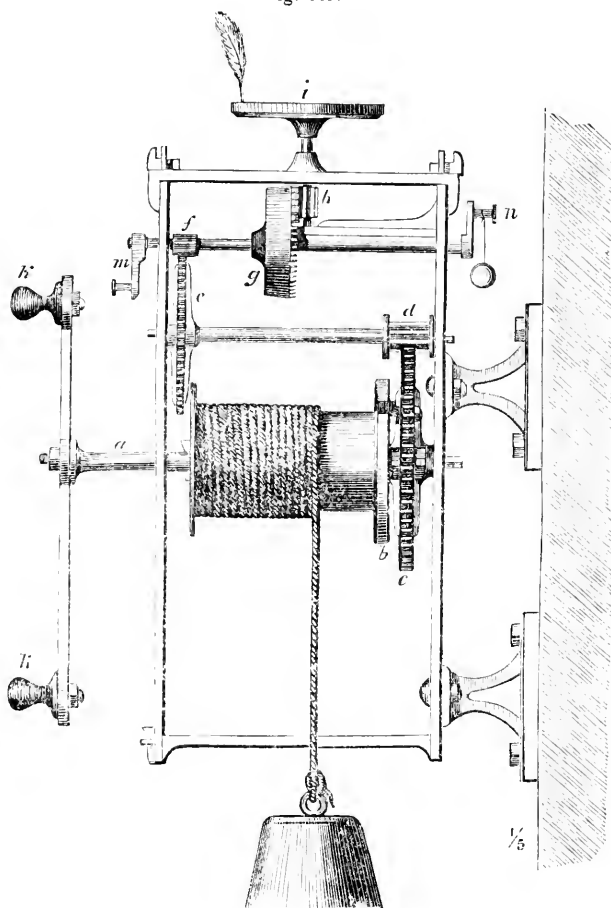


Fig. 119.



APPARATUS FOR STIRRING EXTRACTS.

arrow, as is the case in winding up the machine, the spindle will turn

without carrying the wheel *e* with it; but when drawn in the other direction by the weight, as is the case when the machine is in action, the wheel *e* is carried with it in consequence of the detent, and all parts of the apparatus are thus put into motion.

The wheel *e* bites with sixty teeth in the pinion *d* of the second pivot. This pivot carries the wheel *e* which bites with sixty teeth into the pinion *f* on the third pivot, to which is also attached the contrate wheel *g*, giving motion through the pinion *h* to the fly-wheel *i*. This fly-wheel consists of a disk of wood with a feather stuck in it, which serves as a balance-wheel or regulator to the machine. Thus, if the feather be placed edgewise with reference to the direction of the movement, it will offer little resistance to the rapidity of the motion, and as a slower action is required, the feather is turned so as to impede the motion by the opposing force of the air.

On the third pivot, which carries *f* and *g*, there are at the opposite extremities two small winches *m* and *n*. The latch *g* (fig. 118,) is made to fit with a notch on to the projecting pin of *m*, and in this way motion is communicated from the machine to the spatula *s*, of the stirrer. A counterpoise weight is suspended from the winch *n*, which equalizes the accelerating and retarding influence of the weight of the latch.

The stirring bar (fig. 118,) is suspended vertically over the centre of the large opening in the boiler on which the pan is placed. An iron bracket *a* is fixed to the ceiling, and from this the stirring-bar is suspended by means of a pin, so as to admit of its motion to and fro. The length of the spatula is regulated by the pin *k*, while the extent of its motion is regulated by the pin *o*, which by elevating or lowering this end of the latch lengthens or shortens the stroke of the stirring bar.

The spatula s may be changed to suit the substances operated upon. Thus, for extracts, a wooden spatula may be used; for solutions of salts, one of glass or porcelain should be substituted; and for alkaline solutions, an iron or silver one.

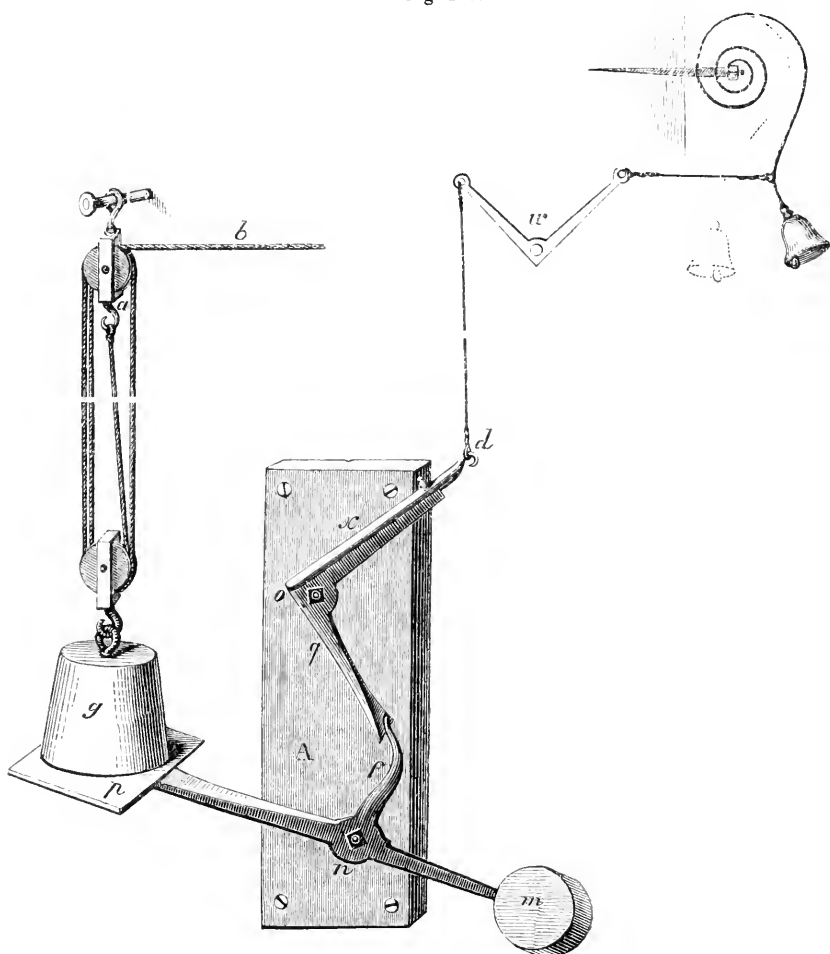
The length of time during which this stirring-machine will continue in motion without re-winding, will of course depend on the length of the line as compared with the circumference of the barrel on which it is wound. The weight may either hang vertically from the barrel, as shown in the drawing, or it may be suspended by a single or double tackle from a more elevated position.

The weight attached to the stirrer I have in use is 40lb., and this is suspended by a compound tackle from a height of twelve feet. With

this arrangement the machine continues in motion for three hours. When my apparatus was first fixed, the cord being shorter, the motion was maintained for only one hour, and it was frequently found that the machine ran down, and the liquid remained unstirred for some time before the attention of the laboratory-man was attracted to it. Even when the continuance of the action was extended to three hours, the cessation of motion was occasionally found to escape observation, so that I was led to contrive an alarum that should always indicate, in a manner that could not fail to be noticed, when the machine required re-winding.

The alarum is represented in fig. 120. It is fixed close to the floor,

Fig. 120.



LABORATORY ALARUM.

immediately under the descending weight. The principal parts of the mechanism of the alarm are attached to a board *A*, which is fixed against the wall. The weight *g* as it descends comes on to the plate *p* fixed to one end of a bar of iron working on a pivot *n*, and having a counterpoise *m* at the other end. The plate *p* being pressed downward by the weight, the arm of the lever *f* communicates motion to the cranks, *q*, *o*, *x*, and *w*, and on its passing the end *q* of the first crank, the spring of the bell is thrown into active motion and the alarm sounded.

This alarm has been found to be efficient; it works well, and is audible throughout the house; and if there be but one assistant engaged, he will immediately be informed, even if he be at the counter, that the stirrer requires re-winding.

When the apparatus is not in use, the lower end of the stirring-bar may be fixed up against the ceiling, so as to be out of the way, and indeed the whole of the mechanism should be fixed at such a height as not to interfere with any other operation that may have to be performed.

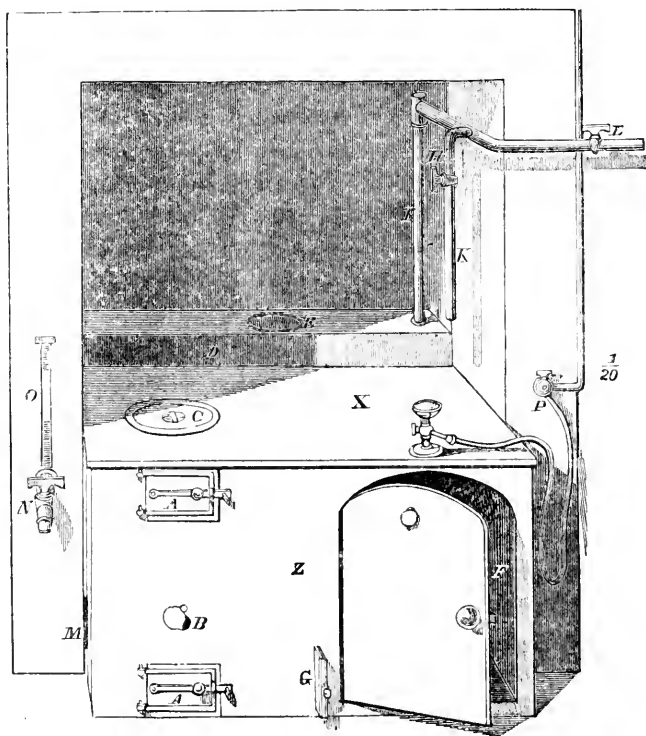
The mechanism of an old clock or a roasting jack, may be used for constructing a stirring machine.

The effect of agitation in promoting the evaporation of a liquid is very marked. I have calculated, that, in making extracts with the apparatus here described, the evaporation will be at the rate of about one pound of water in an hour; so that, if the process be commenced at eight o'clock in the morning, about fourteen pounds of water may be evaporated by ten o'clock at night.

The Beindorf apparatus possesses advantages in its cheapness, the small space it occupies, the numerous purposes to which it is applicable, and the facility with which the several parts are put together or disconnected. But, on the other hand, it is subject to some objections, the most serious of which is, that the steam cannot be put under sufficient pressure to admit of its use for some purposes to which it might otherwise be advantageously applied. The size of this apparatus is also, in some cases, found insufficient to enable it to meet the requirements of the laboratory, and this would certainly be the case where there is much work to be done. With the view of meeting the latter objection, a double apparatus is sometimes used; but instead of resorting to this expedient, I would rather recommend the adoption of an entirely different arrangement, and the substitution of a proper steam boiler to which the different apparatus may be attached by pipes. (See page 129.)

Fig. 121 represents a useful kind of stove, which may be fixed in the fireplace either of the shop, or more conveniently of a room adjoining to the shop. It consists of a chemical furnace, drying closet,

Fig. 121.



REDWOOD'S PHARMACEUTICAL STOVE.

- | | |
|--|---|
| A. A. The furnace and ash-pit doors. | H. The flue from the furnace fire. |
| B. Circular opening into the fire, for clearing the bars, inserting a tube, &c. | I. The steam-pipe. |
| C. Circular opening to the top of the furnace. | K. L. Two branches from the steam-pipe. |
| D. The boiler. | M. Channel for conveying air round the back of the fire into the drying closet. |
| E. Circular opening into the boiler, with a dished cover, and water-joint. See fig. 122. | N. The tap for drawing water from the boiler. |
| F. The drying closet. | O. Tube for indicating the height of the water in the boiler. |
| G. A sliding door or damper, for opening or closing a communication between the drying closet and ash-pit. | P. Gas pipe, with flexible tube, and burner. |
| | X. Z. Cast iron front and top to furnace. |

and boiler for the supply of hot water and steam, with provision for carrying steam or noxious vapours, from any process, up the chimney.

I have arranged this furnace with a view to its being economically and easily constructed. The top plate X, and the front with doors and return ends Z, should be of cast iron, half an inch in thickness. It would be necessary to have patterns made in wood from which to make these castings, but if it be a consideration to construct it at the least possible cost, the front may be made of brick, thus dispensing

with the outer cast iron case; and the doors for the furnace, ash-pit, and drying closet, may be bought, ready made, at any ironmongers. The drying closet door is such as is commonly used for the oven fixed in kitchen ranges. The boiler D is also kept by most ironmongers. The drawing is made from one of those manufactured by the Carron Company of Thames Street, London; it is three feet six inches in length. The pipes for supplying and drawing off the water, and also the steam-pipes are attached in the usual manner. The supply of water to the boiler may be regulated by a cistern with a ball-cock, similar to those adopted for kitchen ranges, or by a ball or stone float in the boiler itself similar to those generally used with steam boilers. The former of these plans is perhaps the least expensive, and most easily effected in country places; it is, however, subject to this objection, that in using the steam, a certain amount of pressure is required in the boiler, which will force the water into the supply cistern, and sometimes cause it to overflow there. This result may be obviated by having a stop-cock between the supply cistern and the boiler, so that, when pressure is required, this communication may be cut off. In this case, and indeed under any circumstances, it would be desirable to have a glass tube O, for indicating the height of the water in the boiler. One end of this tube is inserted into the pipe of the tap N, and the other end communicates by a

Fig. 122.

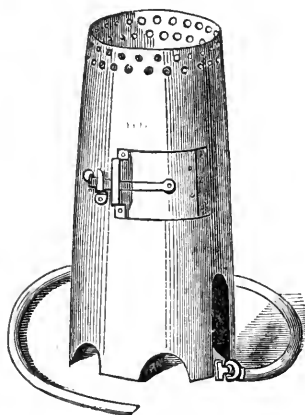


WATER-JOINT.

piece of metallic tube with the upper part of the boiler. The opening E, in the top of the boiler, may have a dashed cover fitting on with a water-joint, as shown in fig. 122. This would prevent the escape of steam under ordinary circumstances, and would act as a safety-valve by allowing it to escape, if unusual pressure were applied, while at the same time it might be used as a water-bath for the reception of an evaporating dish. The water-joint would be inapplicable, however, if the steam were required to be used under more than a very slight pressure. It would be the most simple and inexpensive way of fitting the boiler, but tight joints and a proper safety-valve would render it more complete and generally useful, and would be necessary for some of the applications we are about to notice. The ash-pit door should be made to fit as close as possible, so that the admission of air here may be shut off at pleasure. The furnace door should be

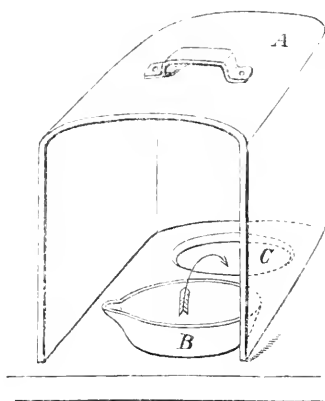
close to the top plate, as shown in the drawing; and there should be a small opening, B, immediately over the furnace bars, to admit of the clearing of the bars with a poker, of sending a blast of air into the fire from a bellows or blowing machine, of introducing a tube into the fire, warming a plaster spatula, &c. Between the drying closet and the ash-pit, there is a communication which may be opened or closed by means of the sliding door or damper G, and at M, there is an air-channel passing round the back of the fire and under the boiler to the drying closet. The course of this air-channel is further shown in fig. 125 at F. When the furnace is in action, if the ash-pit door be shut, and the damper G, drawn out, the air supplied to the fire will be necessarily drawn from the drying closet, while fresh air, warmed by its proximity to the fire, will at the same time enter the closet through the channel M. A constant current of warm dry air will thus be maintained through the drying closet, which will render it very efficient for the purposes to which it is applied. The circular opening C, in the top of the furnace, will receive a pan, small still, or other similar vessel. Decoctions may be boiled in flat-bottomed saucepans merely placed on the hot plate over the flue, a little further back than the opening C. The top of the boiler may be used for any process to which it is applicable, requiring the heat of boiling water.

Fig. 123.



GAS-FURNACE.

Fig. 124.



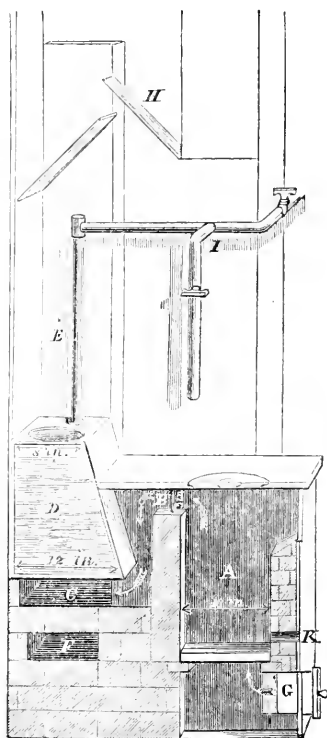
FURNACE HOOD.

The iron plate forming the top of the drying closet at X, will have only the slight heat which it acquires by conduction from the fire. Processes involving the liberation of noxious vapours, may be conveniently conducted here, as the vapours will pass up the chimney. The gas-burner and flexible tube, as shown in the drawing, may be required in some processes of this description, as also the gas-furnace (fig. 123),

which is placed over the gas-burner, and forms a support for a dish, flask, or other vessel. In some cases, however, the furnace-hood, (fig. 124,) will be found to form a better arrangement for getting rid of noxious vapours. It is made of tin-plate, and is placed, as represented, on the top of the furnace over the circular opening C, while the vessel from which vapours are disengaged stands a little in front of the opening.

Under these circumstances, the vapours rising from the dish will be drawn into the furnace as indicated by the arrow. If the furnace be well constructed, this effect will be complete; but, should there be any defect in the draught, it may be necessary to close the ash-pit door, in order to insure the desired result.

Fig. 125.



SECTION OF PHARMACEUTICAL STOVE.

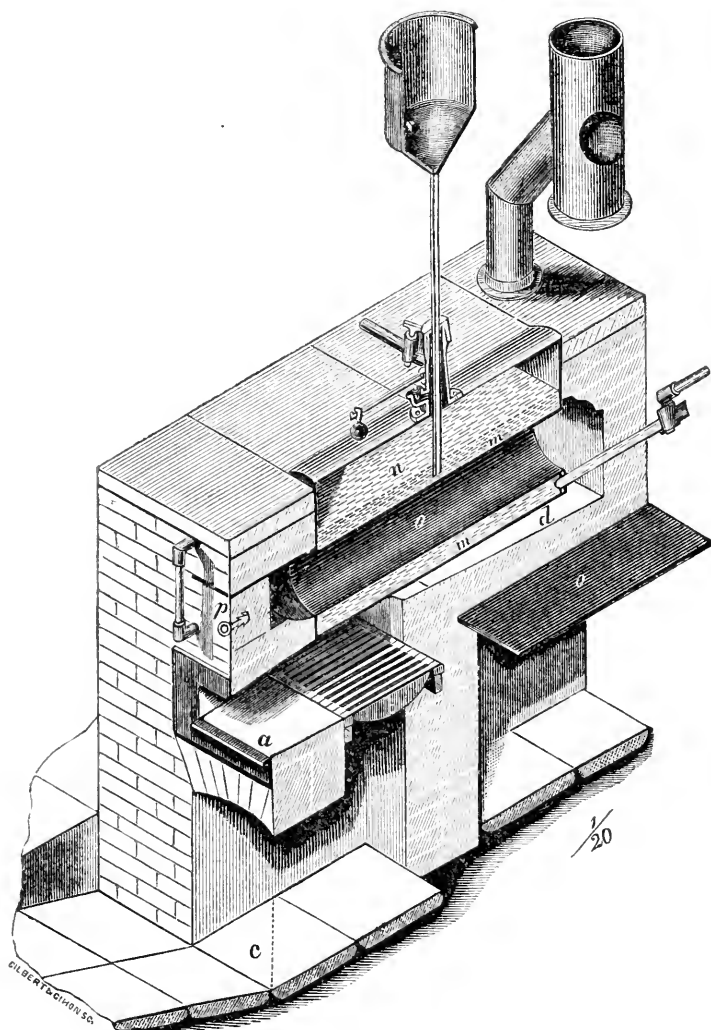
- A. The fire-place.
- B. The flue passing under the top plate of the furnace.
- C. The flue passing under the boiler.
- D. The boiler.
- E. The steam pipe with the branch F.
- F. The air channel leading to the drying closet.
- G. The communication between the drying closet and the ash-pit.
- H. The chimney plates for preventing the soot from falling on to the furnace.

Fig. 125, represents a section of the pharmaceutical stove, through the fire-place and boiler. It shows the arrangement by which steam and other vapours are allowed to pass up the chimney, while the soot is prevented from falling down. This arrangement consists of two plates of iron, fixed as represented at H, one against the back, and the other against the front wall of the chimney.

This pharmaceutical stove will thus admit of many useful applications, even when constructed in the most simple and inexpensive manner, with the water-joint valve. If, however, the joints be all made tight, and a safety-valve, capable of sustaining a pressure of three or four pounds to the inch, be attached to it, it would be susceptible of still further appliances. The steam generated in the boiler, which cannot be forced through pipes, so as to be fully available for use, unless exposed to some pressure, might, under the arrangements now contemplated, be used for making decoctions, warming a drying closet, supplying distilled water, and finally for warming the shop. The means of applying it for the three first-named

purposes, will be described under the head of Steam Apparatus for the Laboratory; the last is that alone which will require special notice here.

Fig. 126.



STEAM BOILER.

- a.* The fire-place, with the door removed.
- b.* The grate.
- c.* The ash-pit.
- d.* The fire-flue passing under the boiler.
- e.* The fire-flue returning through the boiler.
- m, m.* The water in the boiler.

- n.* The space for the steam, above the water.
- o.* A cast-iron plate covering an empty space, left for the purpose of saving bricks.
- p.* A movable brick, to be taken out for the purpose of cleaning out the flue.

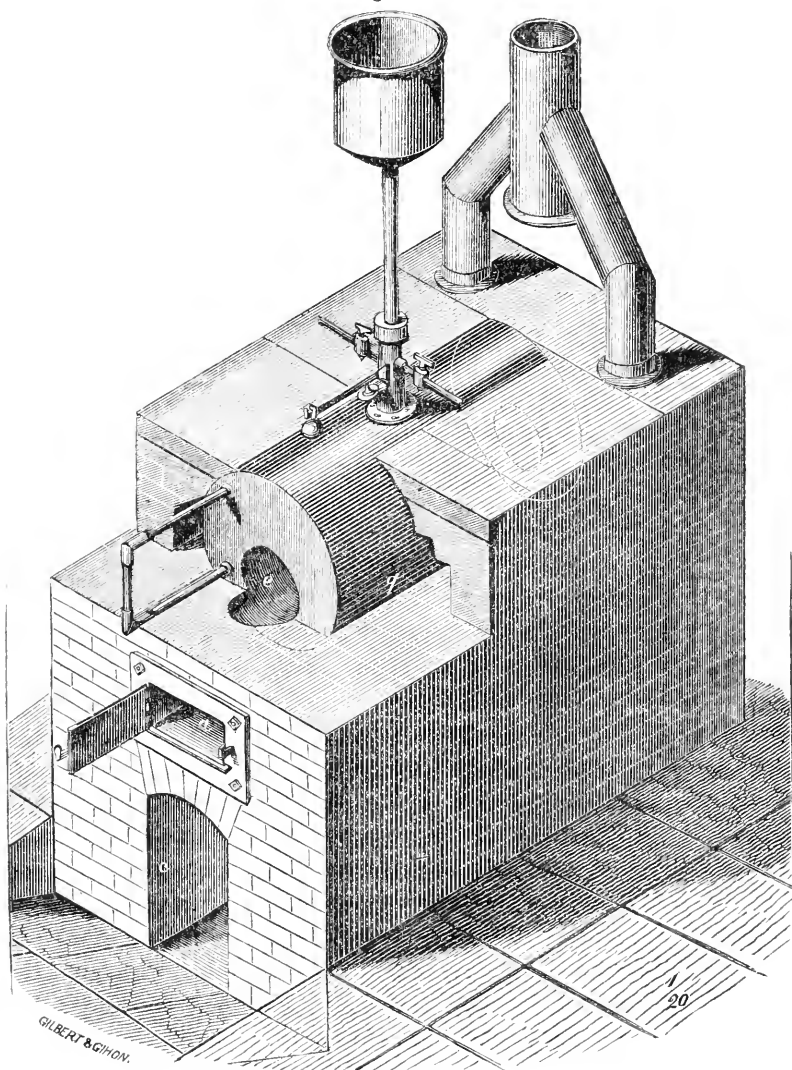
Figs. 126, 127, and 128 represent a cylindrical boiler, with the fire-flue passing through it, which is the form most frequently adopted on

the large scale, as it insures strength to the boiler, and economy of heat.

Fig. 126, shows the manner of setting this boiler.

The flue which returns through the boiler, divides into two in front, and then passes backward on each side of the boiler.

Fig. 127.



STEAM BOILER.

q, q. The two lateral flues.

e. The interior flue.

Fig. 127, gives another representation of the boiler, with part of the brick-work removed from the front.

This figure shows the way in which the glass tube for indicating the height of the water, is connected with the boiler by means of two copper tubes which pass through the brick-work.

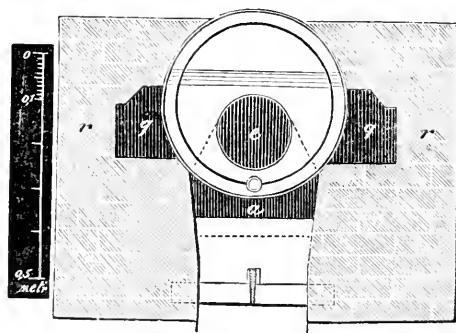
This and the preceding figure also show the large funnel-pipe for supplying water to the boiler, the pipes for conveying away the steam, and the safety-valve, which are all inserted in one place.

Fig. 128 represents a vertical section of the boiler and brick-work. This figure is drawn to a smaller scale than the two preceding figures, in the proportion of nine to eleven.

It is questionable whether this would be the best form of boiler to adopt in a pharmaceutical laboratory; but undoubtedly, whether this or a different form be selected, it ought to have such fittings as would admit of the steam being used

under some degree of pressure, without which it would not be susceptible of application to the full extent required. The cylindrical boiler with the fire-flue passing through it, is certainly the most economical with regard to heat, but it presents much more difficulty than the plain cylindrical or wagon-shaped boiler does, to the removal of the incrustations of carbonate of lime which are deposited on the inner surface. For this reason I prefer one of the two last-named forms. The boiler may be made entirely of wrought iron, if economy in price be a consideration; for although it is sometimes stated that the steam acquires a disagreeable smell when generated in an iron boiler, and that this is communicated to the condensed water, I have never experienced this evil, after using one of these boilers for chemical and pharmaceutical purposes during many years. It should be provided with a man-hole, to admit of its being from time to time properly cleaned out; and, above all, it ought to have a self-acting feed-pipe, by which a uniform supply of water may be always maintained in it. Of course it is necessary that the cistern from which the water is supplied to the boiler should be elevated to such a height that the column of water in the feed-pipe shall exercise a pressure greater

Fig. 128.



SECTION OF STEAM BOILER.

a. The flue running under the boiler.

e. The internal flue.
q. q. The lateral flue.

than that to which the steam is intended to be submitted. These arrangements, however, are well understood by those who supply and fit up steam boilers.

[Where the operations carried on are large, and the demand for steam great, the boiler represented at fig. 127, or the ordinary tubular locomotive boiler, may be used with great advantage; but in a pharmacist's laboratory, where he has not constant use for his steam apparatus, there is no arrangement that I have met with superior to that of Shoemaker and Smull of Baltimore. This apparatus, of which fig. 129 is a representation, is constructed in the following manner. A, B, fig. 129, is the cylindrical boiler, enclosing the fire-place or furnace, which boiler rests on a square base or ash-pit, C, of cast iron, but to which it is not attached. The fire-chamber is completely surrounded by water, except the space occupied by the door at B, the sides being double, and made of stout boiler iron, as also is the superior portion. At D, is a strong band of iron surrounding the boiler to increase its strength.

The products of combustion and heated air, are carried off through nineteen tubular flues, $1\frac{1}{2}$ inches in diameter, which pass directly through the centre of the boiler, as shown at *a* in the sectional view,

Fig. 129.

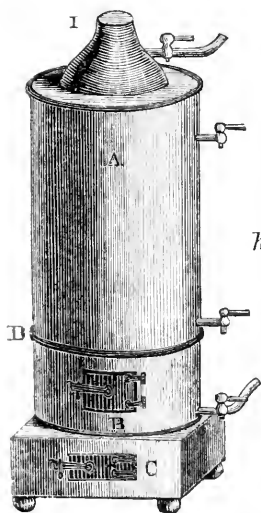


Fig. 130.

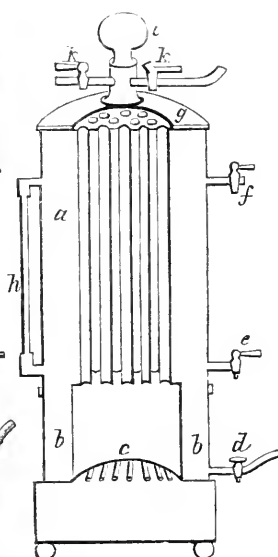


Fig. 131.

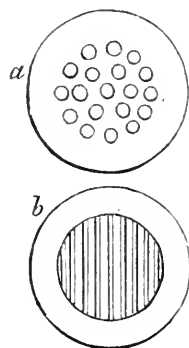


fig. 130. The grate, *c*, is about one inch above the bottom of the boiler, and at this point the cold water to supply the waste, enters by the hydrant cock *d*. *e* and *f* are cocks; *f* indicating the highest point to which the water is allowed to rise: *e* the lowest to which it is

suffered to fall. In filling the boiler, the upper cock is left open, and the water permitted to run in at *d*, till it begins to run out at *f*. The glass tube, *h*, may be used to indicate the height of the water in the boiler at a glance. Fig. 131, *a* and *b*, exhibits transverse sections of the boiler through the upper and lower parts. The boiler is surmounted by a cast iron cone, *I*, fig. 129, which is connected with a chimney by a pipe. *i*, *k*, *k*, fig. 130, represents the safety-valve, and the two exit pipes for conveying the steam to the apparatus to be heated. The valve is loaded with a nine pound weight, which is lifted when the pressure becomes more than seven pounds per square inch. *k*, *k*, are the exit pipes for the steam. This boiler requires about 30 gallons of water, and is chiefly valuable for its compactness and the rapidity with which it can be put into operation. In one hour from the time of commencing the fire, seventy-five gallons of water can be made to boil in another apartment, with a pressure of five pounds of steam. The supply of steam is sufficient to carry on several operations at the same time, in large vessels.—W. P.]

In adopting a steam boiler for laboratory use, it is an important question to determine what ought to be its size. The economy and satisfaction in the use of it will mainly depend on the adaptation of the size of the boiler to the work required to be done by it. The calculation generally acted upon is, that a boiler having a bottom surface of four or five square feet, if well set, will vaporise a cubic foot, or about six gallons, of water per hour. If, however, the steam be required under pressure, the quantity generated will be proportionably less.

There are few cases where it is intended to be practically applied in a pharmaceutical laboratory, in which it would be wise to have a boiler of less capacity than thirty or forty gallons; and from this up to a hundred gallons may be considered to comprise the sizes best adapted for the purpose contemplated.

The steam boiler is intended to supersede, almost entirely, the necessity for other means of heating, by the use of furnaces; but, to accomplish this to the fullest extent practicable, the boiler and apparatus must admit of the steam being used under a pressure varying from five to ten pounds on the square inch.

The boiler will be in daily, or almost daily use, this being one of the conditions contemplated, and it will generally be the only source of heat in the laboratory. It is very desirable and important, therefore, so to arrange the apparatus, that the heat generated here may be economised as much as possible, by applying it in the most efficient manner to the most useful purposes.

In setting the boiler, it will be found advantageous, instead of enclosing it almost entirely in brick-work, as shown in fig. 127, to have the upper part, to the depth of a few inches, covered with sand, so as to form a sand-bath. This, from the equable temperature at which it will be maintained, will be very useful in a variety of processes.

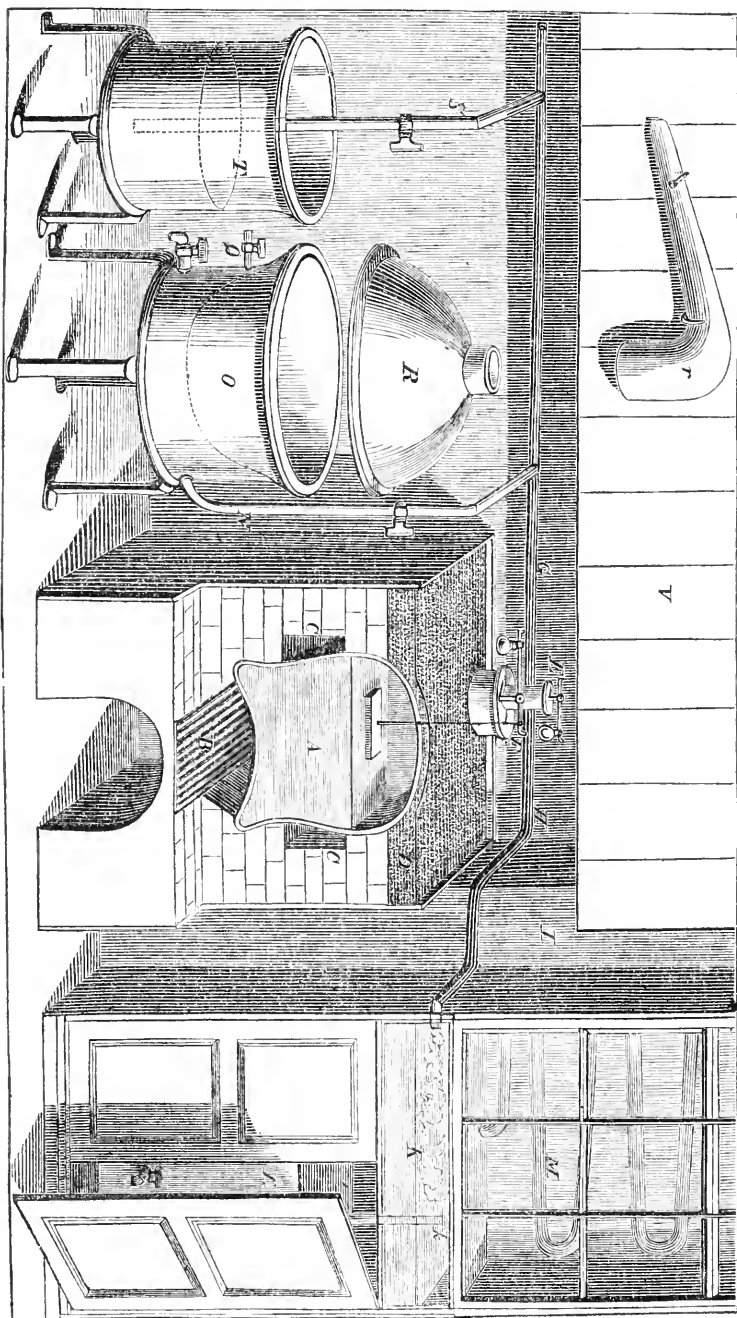
The chimney of the furnace should be made, if possible, to abut upon a drying closet, which would thus derive some of the unexpended heat of the fire. The closet may be further heated by means of a steam-box, of similar form to the box of Mohr's drying closet, described in the chapter on EVAPORATION. This box may either be fixed as there shown, or it may form the bottom of the closet. It should be made of copper, well tinned on the inside, and should be connected with the boiler by a steam-pipe of rather large diameter, the termination of which in the box should be near the top, so that the condensed water which collects there may not run into the boiler, but be conveyed by a *tin pipe* into a vessel suitable for its reception. A *tin pipe* may also be carried from the top of the steam-box, and made to traverse the back of the closet in a serpentine direction, being finally terminated at the upper end by a valve. In this way the closet would be efficiently heated, while pure distilled water would at the same time be collected; and by fixing a cock near the bottom of the steam-box, distilled water at a boiling temperature may at any time be obtained from this source.

The other purposes to which the steam may be applied are those of boiling, evaporating, distilling, and melting, or otherwise heating the several substances operated upon in the laboratory. In performing these operations through the medium of steam, as the means of communicating heat, it is necessary to employ apparatus expressly adapted for its application. The kind of apparatus suitable for this purpose is represented in the drawing fig. 132.

The process of *boiling* is conducted either in the jacketed pan O, or in the vessel T.

In the former case the ingredients are put into the pan and heated by the application of steam, which is conveyed by the pipe N to the chamber beneath. On first turning the steam on, by means of the stop-cock, it is necessary to allow the air previously occupying the steam chamber to escape through the valve Q, which is subsequently closed. The water which will condense in the steam chamber must, from time to time, be allowed to run off at the tap P. In boiling in this way, it is necessary to have the steam under a pressure of five or six pounds to the inch, otherwise the required heat will not be com-

Fig. 132.



A. The boiler.
 B. The fire-place.
 C. The lateral flues.
 D. The sand-bath.

E. The safety-valve.
 F. The lever attached to the stone float.
 G, H, M, N, S. Steam pipes.

I. The chimney.
 K. The steam-box of the drying-closet.
 L. The cistern for distilled water.

O. The evaporating pan, made of block-iron, the outer case, or jacket, being of cast-iron.

R. The cover of the pan, converting it into a still.
 T. The still-bed.
 V. Boards enclosing the space over the apparatus.

municated to the contents of the pan; and much heat is lost during the process by radiation from the outer case, or jacket, of the pan.

A more economical, and often very convenient method of boiling, is that which is conducted in the vessel T. In this case the substance to be operated upon is put into the vessel, to the bottom of which a steam-pipe (S) passes, and steam is allowed to escape from the end of this pipe. In some instances it is found advantageous, on commencing the process, to let the steam pass through the dry ingredients for a few minutes before adding any water, the effect of this being to cause the substance to swell out, and better admit of the subsequent penetration of the water. When the water is added, allowance must be made for the increase which will take place from the condensation of steam in the vessel, for in this case the effect of continuing the process is the reverse of that which occurs in boiling in the pan O. The operator, instead of commencing with more liquid than the decoction is intended to measure when finished, and boiling down to that measure, commences with a quantity less than is required, and boils up to the proper measure.

The pharmaceutical stove (fig. 125) might be applied for the preparation of decoctions in this way, a suitable vessel being so placed that the pipe K shall reach to near the bottom of it.

The process of *evaporation* is conducted in the pan O. A mechanical stirrer may be used for expediting the process; but there are certain precautions which it will be necessary to observe in the use of this instrument in the evaporation of extracts, which will be further alluded to hereafter.

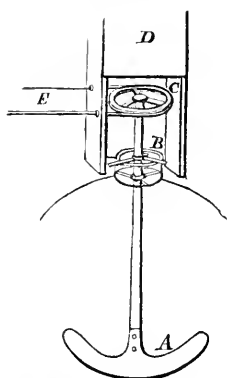
There is perhaps no process in the pharmaceutical laboratory that occasions so much annoyance, in the way in which it is usually conducted, as that of evaporation, and this arises from the large quantity of steam generated, which fills the apartment and often interferes injuriously with other operations. It is very important, if possible, to get rid of this steam and prevent its diffusion into the room. This might be done by putting the cover R on the pan, and fixing a pipe to the opening in the top, so as to convey the vapour into the open air. The pan would be thus converted into a still, and the evil alluded to entirely prevented; moreover, there would be a manifest advantage in conducting the process in this way, inasmuch as the substance under operation would be less exposed to the action of atmospheric air than it would in the open pan. There are, however, some difficulties in the adoption of this arrangement, which require to be met by special provisions. If the steam has to be conveyed to a height of

many feet above the pan, much condensation will take place in the pipe, and the process of evaporation will thus be considerably retarded. This evil may be obviated in the following manner:—Instead of fixing the cover R on the top of the pan, as would be done in distilling, three or four blocks of wood, about four inches deep, are placed on the rim of the pan, and the cover is made to rest on these, so that there shall be an open space to this extent all around between the pan and the cover. The air enters freely through this opening, and mixing with the steam at an elevated temperature, they pass off together through the pipe above. The pipe ought to be at least six or eight inches in diameter, so as to admit of a large volume of air passing off with the steam, in which case little or no condensation will take place. The space between the pan and the cover admits also of the introduction of a stirrer to be worked with the hand. This plan answers very well for getting rid of the steam, but while the difficulty arising from the condensation of vapour in the steam-pipe is thus obviated, the evil of admitting atmospheric air into the pan is at the same time effected. Another, and probably a preferable arrangement, might therefore be adopted, which consists in fitting the cover to the pan without the blocks, and placing over the opening at the top a large pipe, with a space left open as in the other case, for the admission of air, into which the vapour may diffuse itself. A square wooden shaft, about eight or ten inches in diameter, may be used for this purpose.

If the cover of the pan be thus fitted on, it would be necessary to provide means by which the progress of the inspissation might be observed. The best method of effecting this is to have two circular pieces of strong plate glass fixed in two opposite sides of the cover R, as shown in the vacuum apparatus at O, described at DISTILLATION. The light entering at one of these windows, is reflected from the surface of the liquid in the pan, and passes out through the other window, thus enabling the operator to see the contents of the pan.

With the arrangements now under consideration, it would also be necessary to have a mechanical stirrer for agitating the liquid during evaporation. Fig. 133 represents the kind of stirrer that would be most conveniently applied. The agitator (A) may be made either of block-tin or of wood. It is suspended by a frame placed on the opening in the cover of the pan at B, so that the arms of the agitator shall not come in contact with the sides of the pan; and a rotatory motion is given to it by means of a cord (E) passing round the wheel C. The manner of fixing the wooden shaft (D) is also shown in the drawing.

Fig. 133.



MECHANICAL STIRRER.

The process of *distillation* is conducted in the pan O, which is converted into a still, by fitting on the cover R, and the still-head *r*. The refrigerator is not shown in the drawing; it might conveniently stand beyond the vessel T. The kind of refrigerator that I have been accustomed to use is constructed on the same principle as that represented in the vacuum apparatus. A common block-tin worm is fixed in a wooden or metallic case, of little more than the dimensions requisite for holding it. The case is covered at the top, so as to be perfectly water-tight; and a pipe communicating with a cistern supplies cold water to the bottom of this vessel, while another pipe conveys away the heated water from the top. This latter pipe may convey the hot water to a second cistern underneath the floor, or it may deliver it for use at the sink. While the process of distillation is proceeding, the water must be constantly running through the refrigerator. By this arrangement two of the greatest inconveniences attending the use of the common worm-tub are obviated.

In most pharmaceutical laboratories fitted up on the old-fashioned principles, the most striking object on entering the apartment is the worm-tub, which, being designed to hold the supply of water required for all the processes of distillation, is necessarily of very large dimensions, and often occupies space that cannot be conveniently spared. This worm-tub is open at the top, and, as the water heated during the process of condensation rises to the surface, the upper strata of water are often at a temperature near the boiling point, and consequently a large quantity of steam is given off from the worm-tub when in use. The size of the worm-tub, and the disengagement of steam from the surface of the water when it is in use, are, therefore, the two evils alluded to which are obviated in the arrangement I have recommended.

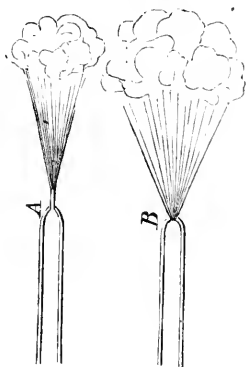
The pan O may be further used for any operations involving the application of a temperature not much exceeding that of boiling water, such as the preparation of plasters, ointments, &c.; but it would generally be found more convenient to have a separate pan of similar construction for these purposes.

In addition to the means already pointed out for getting rid of the steam generated during the processes of evaporation, there is another method which may be conveniently and successfully applied in some

cases, and which will also at the same time promote the general ventilation of the apartment. This means is dependent upon the use of a jet of high-pressure steam, and therefore can only be applied where there is a steam boiler with a constant supply of steam under a pressure of eight or ten pounds to the inch.

It has long been known, that, if any gas or vapour be forced with much pressure through a tube, having a small aperture at the end, immediately on issuing into the air it will expand into a cone, as shown at B, fig. 134; whereas, if propelled with a very slight pressure, it will maintain a cylindrical form for some distance after issuing from the tube, but will still ultimately expand into a cone, as shown at A, fig. 134. The conical expansion in both cases

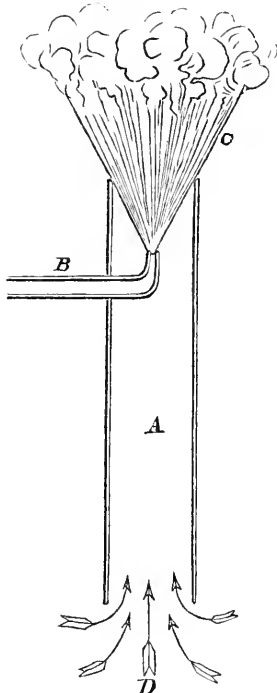
Fig. 134.



STEAM JETS.

Fig. 135.

has been found to arise from the admixture of the surrounding air, which is mechanically drawn into the propelled jet, the amount of air thus drawn in, and the consequent expansion of the cone, being greater in proportion as the force with which the jet is propelled is increased. The knowledge of these facts has been applied in effecting the ventilation of apartments, a strong current of air being determined through a tube or shaft, by discharging a jet of high pressure steam at one end of it, as shown in fig. 135. A is a cylinder nine or ten inches in diameter; B, a steam-pipe, the orifice of which is one-sixteenth of an inch in diameter, fixed at such a point that a jet of steam issuing from it shall expand to the full circumference of the cylinder on reaching its mouth. Under these circumstances air is drawn with great force into the cylinder from below, as indicated by the arrows, and passes off in admixture with the steam. The size of the apparatus may, of course, be varied to suit the different circumstances under which it may be applied.



CHAPTER V.

COMMUNITION. COARSE COMMUNITION OF VEGETABLE SUBSTANCES.
PULVERIZATION. GRANULATION. ELUTRIATION.

COARSE COMMUNITION OF VEGETABLE SUBSTANCES.

A GREAT number of vegetable substances are prepared for use by submitting them to coarse comminution. They are employed in this state for making infusions and decoctions, and many are also sold, under the name of *species*, for the purposes of private dispensing. The term *species* is properly applied to a mixture of several kinds of vegetable substances, but such a mixture cannot be made, so as to be uniform, without reducing all the ingredients to an equal degree of comminution. This particular kind of comminution has latterly been looked upon as the distinctive character of what are called *species*, and the term is, therefore, now frequently applied to coarsely comminuted vegetable substances, even when consisting of only one kind.

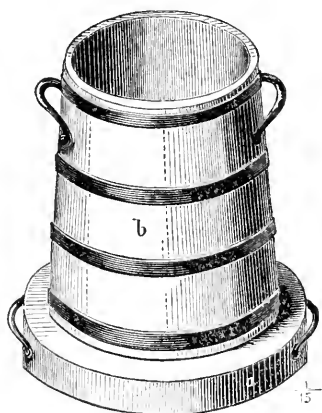
The means by which comminution is effected, are chosen according to the nature of the substances operated upon, and the purposes to which they are applied. If the process be adopted for the preparation of vegetable substances as *species*, much care should be taken to reduce the particles to as equal a size as possible, and for this purpose the *cutting* or *slicing-knife* is generally employed. If the substance should consist of flowers, leaves, or herbs, these are most easily comminuted by means of the *rolling-knife* or *cradle-knife*. On the other hand, if the object of the process be to cut hard woods, roots, or barks, preparatory to their being powdered, the *chopping-trough* may be advantageously used. The substances cut with the last-named instrument will not be reduced to fragments of equal size, but in the cases alluded to this is not important.

The *chopping-trough*, (fig. 136,) consists of two separate parts, the bottom, or chopping-board (*a*), and the cylinder (*b*), which rests upon, but is not fixed to, the former. The chopping-board is about twenty-four inches in diameter, and three inches thick. It should be made

of oak, or some other hard, close-grained wood, the fibres of which run perpendicularly, or at right angles with the horizontal surface of the board. It must, therefore, be a transverse section of the trunk of a tree, and should, if possible, be in one piece, both sides of which are planed so that the chopping might be effected on either surface. It is furnished with two handles, as shown in the drawing.

The cylinder, which is placed on the chopping-board when in use, is also made of wood, bound together with iron hoops, and furnished with two handles. It has a slightly conical form, the smaller end being uppermost, and the lower edge planed to a smooth surface so as to fit closely on to the board.

Fig. 136.



CHOPPING-TROUGH.

Fig. 137.

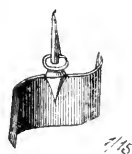


Fig. 138.

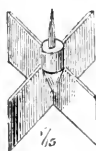
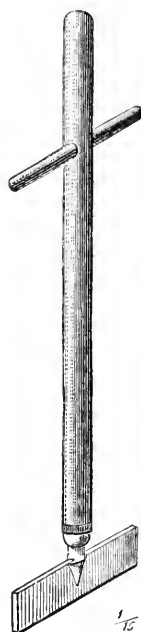


Fig. 139.



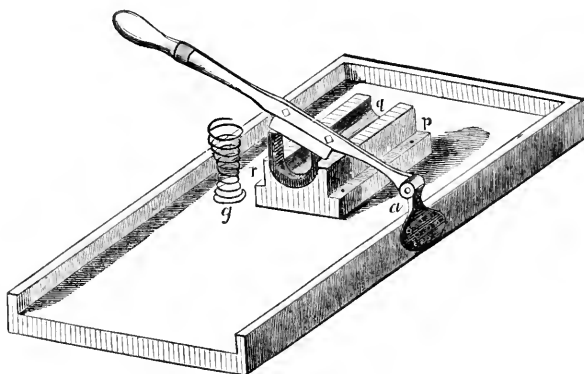
The cutting instrument, or chopper, is made of good steel, and may have the form of any one of those represented in figs. 137, 138, and 139. It is fixed by means of a spike to the end of a stick which forms the handle. This should be strong and rather heavy, and should have a cross-bar near the upper end, as represented in fig. 139, by which it is grasped with the two hands in using it.

The substance to be cut is placed within the cylinder, over the chopping-board, and a series of hard blows are inflicted upon it with the chopper until the requisite degree of comminution has been effected.

The *cutting-knife* or *slicing-knife* is constructed in different ways. The knife itself consists of a one-armed lever attached to a frame or block of wood by a hinge which

admits of motion in two directions, one vertical, the other horizontal, so that several successive slices may be cut from the substance laid on the block without moving it. Much force is required to cut hard woods with this knife. The substance lying on the block grasps the knife on either side, and the blade has to be moved with a force capable of overcoming the resistance caused by friction, in addition to that of the cohesion of the parts yet uncut. By making the blade of the knife slide upon another sharp steel edge, passing in an opposite direction, like the blades of the scissors, the resistance from friction is lessened, as the part already cut is turned out and prevented from impeding the progress of the cutting edge. This method of constructing the slicing-knife has therefore been frequently adopted latterly. Fig. 140 represents a knife which I have constructed on the above principle,

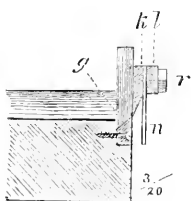
Fig. 140.



CUTTING-KNIFE OR SLICING-KNIFE.

and in which I have also provided means for equalizing the size of the cut pieces. The knife, in this case, moves only in a vertical plane, on the hinge (*a*). The blade of the knife can be removed from the handle, to which it is fastened by screws. This is advantageous, as it facilitates the grinding of the blade, and admits of its

Fig. 141.



being replaced by another in case of its being much damaged. Between the lever-bar of the knife and the blade, a plate of iron is fixed, which may be called the touch-plate. In fig. 141 this is shown in section as seen from the point *r*, (fig. 140,) *k* being the blade of the knife, *n* the touch-plate, *l* the lever to which the handle is attached, *r* the screw securing these together, and *g* the steel edge

fixed to the frame, and against which the knife slides. In fig. 142 the several parts are shown as seen from above, and in fig. 143, as seen from the front, the letters being applied to similar parts in all the drawings.

Fig. 142.

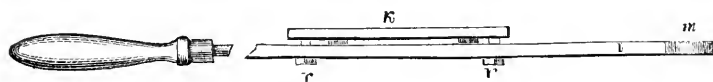
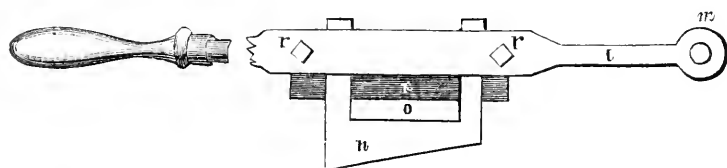


Fig. 143.

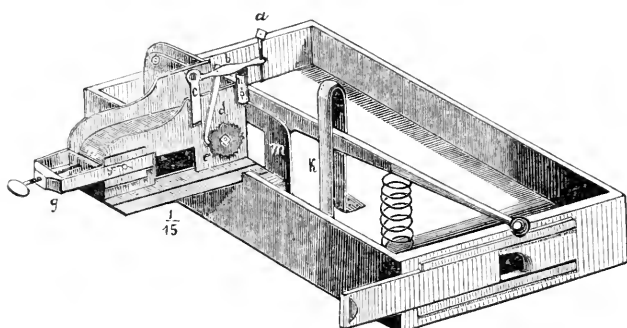


The touch-plate (*n*) moves with the knife, so that on raising the latter it comes in front of the substance to be cut, which is pushed forward until it touches this plate. The knife being now pressed down cuts off the advanced portion, which, on again raising the knife, falls through the opening (*o*, fig. 143). The cutting block (*p*, *p*, fig. 140) is made of a strong piece of wood having a groove (*q*) in which the substance to be cut is placed. Against the front of this groove is fixed a steel plate of the form of a horse-shoe, the sharp edge of which is opposed to the edge of the knife. There is a spring, consisting of a coil of strong wire, such as is used for the seats of sofas and chairs, placed under the lever of the knife, which, being compressed as the knife is forced down, tends to raise the handle when the pressure is relaxed. The knife should also be kept in its place, pressing tightly against the end of the block, by means of a stirrup such as is represented in fig. 144 at *k*. This stirrup and the touch-plate are omitted in fig. 140, in order that the other parts should be more clearly represented.

Fig. 144, represents the arrangement I have adopted for a *self-supplying cutting-knife*. The knife is fixed to the cutting-plate (*m*) by a rivet-hinge, and the two cutting surfaces are brought into lateral contact as the handle of the knife is depressed. The cutting-plate, and the self-acting apparatus for feeding the knife, are fixed to a wooden frame into which the cut substance falls. On lifting the knife it strikes against the lower end of the screw (*a*), and raises this to-

gether with its little lever (*b*). The lever turns on the fulcrum (*c*) and carries a hook (*d*), which bites into the cog-wheel (*e*), thus turning the wheel round its axle to the extent of two or three cogs each time the handle of the knife is lifted. The axle of the wheel (*e*) passes through the box (*n*), within which it carries a wooden roller. Over

Fig. 144.



MOHR'S SELF-SUPPLYING CUTTING-KNIFE.

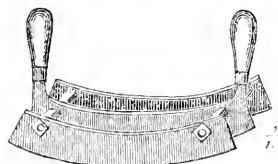
this roller, and over another at *f*, an endless strap is fixed, which is tightened by the screw (*g*), so that on turning the wheel (*e*), the strap is put into motion. The substance to be cut is placed upon the strap, and to the extent to which the strap moves, the substance is carried forward each time the handle of the knife is raised. No motion, however, is given to the strap until the edge of the knife has been raised above that of the cutting-plate, which is a necessary provision, as the substance could not otherwise be pushed forward. When the back of the knife comes against the screw (*a*), and lifts it, the strap is put into motion and the substance to be cut is carried over the edge of the cutting-plate to receive the knife as it descends.

There are two means for regulating the extent to which the substance to be cut is carried over the cutting-plate prior to each incision. One consists in raising or lowering the screw (*a*); the other in altering the position of the support (*h*) on which the lever (*b*) rests. In either case the effect is that the lever (*b*) is elevated, and the wheel (*e*) turned to a greater or smaller extent on raising the knife, and as the motion of the strap participates in this alteration the size of the pieces cut may be thus regulated at pleasure.

The Cradle-knife, consists of two or three curved blades joined together, as shown in fig. 145, and furnished with two upright handles. The substance to be cut is placed on a board beneath the knife, which

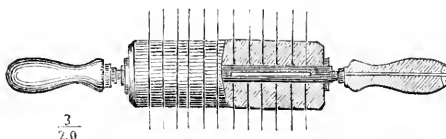
is pressed down by the handles, a greater pressure being applied, first to one handle and then to the other, so as to produce a rocking motion like that of a cradle. Herbs, leaves, and flowers, are thus reduced to small fragments. The cradle-knife, however, is not a very efficient cutting instrument, and Dr. Mohr proposes to replace it by

Fig. 145.



THE CRADLE-KNIFE.

Fig. 146.

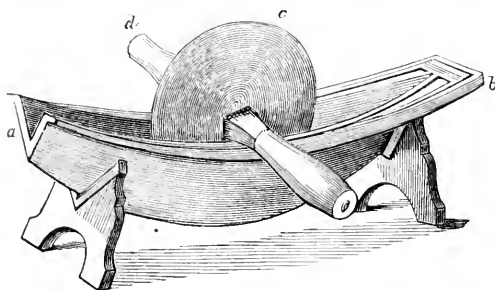


THE ROLLING-KNIFE.

The Rolling-knife.—This instrument is represented by fig. 146. It consists of an iron axle, terminated at each end by a wooden handle, and having a number of circular steel blades fixed on the intermediate part at equal distances from each other, with disks of wood between them to keep them in their proper positions. This knife is used in the same way as a rolling-pin, and is found to be much more efficient than the cradle-knife.

The Chinese use an instrument for cutting or grinding substances used in medicine, which deserves to be noticed here. Fig. 147, represents one of these instruments in the possession of the Pharmaceutical

Fig. 147.



CHINESE CUTTING-TROUGH.

Society. It consists of an iron wedge-shaped trough (*a b*), in which a circular blade (*c*) is rolled by means of the wooden handles (*d d*).

In England, the only instruments commonly employed by the pharmacutists for the purpose of coarse comminution are those described

at pages 34 and 35. The preparation of herbs for use as species, is rarely performed by the druggist, this being the proper business of the herbalist.

PULVERIZATION.

The operations by which drugs are reduced to a fine powder are of considerable importance in connexion with the preparation of medicines. These operations, when performed by the retail pharmacist, are generally conducted in a room set apart for that purpose, and the instruments most frequently employed in the process are the pestle and mortar and the sieve. The porphyry slab and muller are sometimes used, and in a few instances the substance to be powdered is merely rubbed through a sieve. But, in this country, the greater part of the drugs which are used in powder are reduced to that state previously to their passing from the wholesale dealers, and in these cases the process is usually conducted by persons who make it their special business, and who are called *drug-grinders*. The establishments at which drugs are thus reduced to powder on the large scale are called *drug-mills*, and the implements used there for effecting the disintegration of the drugs, are the *grinding-mill* and the *stamping-mill*.

There are, therefore, several methods or processes by which drugs are reduced to powder, the process being varied to suit the nature or the quantity of the substance to be operated upon.

Contusion.—The pulverization of drugs by contusion is usually effected with a pestle and mortar made of some hard metal, such as iron or bell-metal. It is thus, in operating on the small scale, that all hard and tough substances are reduced to a state of disintegration. At the drug-mills contusion is also effected by the pestle and mortar, but the pestle being worked by machinery, the apparatus is there generally called a *stamper*, or *stamping-mill*.

In casting the mortars they are formed after different patterns or designs, but their general character is such as is represented in figs. 148 and 149. The bottom of the mortar should be perfectly flat on the outside, so that it may stand firmly, with a solid bearing; it should also be thicker at the bottom than at the sides. The upper edge is sometimes made like that of fig. 148, with a projecting rim and a groove on the outside, which admits of the leather cover being secured with a cord to this part. In fig. 149 there is a rim of a different kind, intended to receive a wooden hoop or circular frame, to which the leather is tacked, and this frame is fastened down by a cord on two

opposite sides of the mortar. There are sometimes two cylindrical projections from the sides of the mortar, as in fig. 148, by which it is moved, and to which the top might be tied.

Fig. 149.

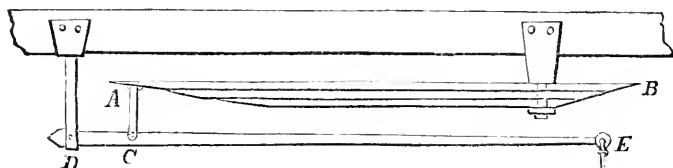
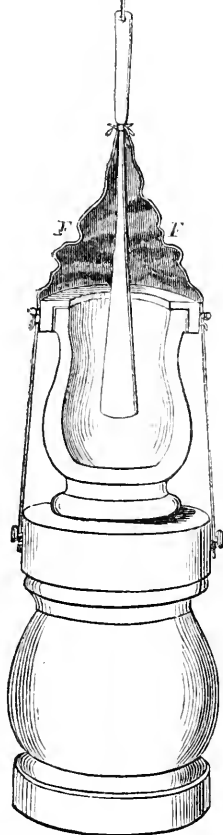
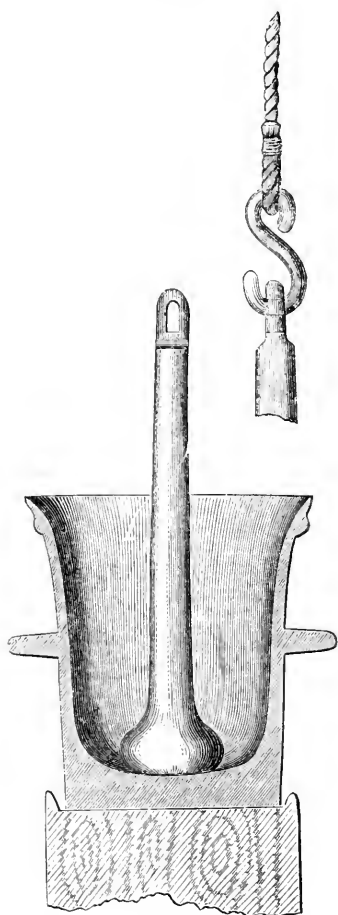


Fig. 148.



MORTAR AND SPRING PESTLE.

The pestle is most frequently made of wrought iron; in some instances, however, it is made of cast iron. It should weigh from twelve

to twenty, or even thirty pounds, the weight varying according to the purpose to which it is applied. The end of it which comes into contact with the mortar should have a curve corresponding with that of the bottom of the mortar. There is a hole or eye at the other end for the reception of a hook, attached by a cord to the spring.

The mortar stands on a wooden block, at such a height that the arms of the operator holding the pestle shall not strike against it.

The labour of lifting the heavy pestle is lessened by suspending it from a spring, which, being bent when the pestle is brought down in contact with the bottom of the mortar, carries it up again by the force of its elasticity, without the aid of the arm. The pestle thus suspended is called the *spring pestle*. The spring generally consists of a thin fir-pole, the thickest end of which is fixed to the ceiling or to the wall, while the pestle is attached by a cord to the other extremity. The length and size of the pole must be suited to the weight of the pestle it is intended to carry.

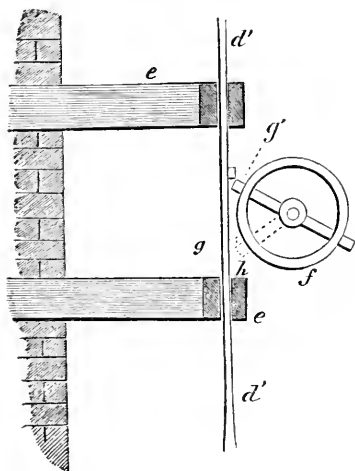
In fig. 149 a spring of a different kind is represented, the construction of which has been already described at page 37.

The spring should be very securely fastened to a part of the building capable of bearing the continued vibration to which it will be exposed.

The pestle and mortar of the drug-mills differ only from those used in private establishments in regard to the manner of raising the pestle. The whole of the machinery being worked by steam-power, the pestles or stampers are raised by projecting arms attached to a revolving shaft, which carries them to a certain height, and then allows them to fall with the impetus of their own weight. The

arrangement by which this is effected is represented in fig. 150, where $d' d'$ is the elongated pestle passing through a frame (e); f is the revolving shaft, the arm (g') of which, when in the position of the dotted lines at h , catches a projection on the pestle and carries it up to the point g' , from whence it falls. There are generally several of these mortars placed in a row, the pestles of which are all worked by the same shaft. In fig. 163, page 158, two mortars or stampers ($b b$) are represented in connexion with other arrangements of a drug-grinding-room.

Fig. 150.



A large and heavy pestle can only be used with good effect when the mortar and its stand are of proportionate size and weight. If the mortar or its stand be too light in relation to the pestle, the blows inflicted by the latter will cause the former to vibrate considerably, without producing an effect upon the substance pounded adequate to the power employed.

In performing the process of pounding, such a quantity of the substance operated upon should be put into the mortar as will form a stratum at the bottom of about three quarters of an inch or an inch in thickness. If more than this be put into the mortar at once, the particles will not be so efficiently comminuted.

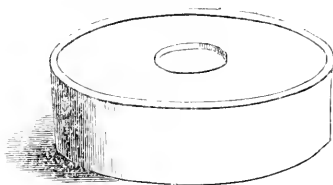
It is generally necessary to have a cover to the mortar to prevent particles from being projected out by the force of the blows, and especially to confine the finer particles which, in powdering some substances, become diffused through the atmosphere, causing loss of product, and often much annoyance to the operator.

The most simple kind of cover for the mortar consists of a circular piece of board of the size of the top of the mortar, with a round hole in the centre, through which the pestle passes, and a broad and flat wooden hoop around the circumference, projecting two or three inches below the lower surface of the board, and fitting loosely over the outer rim of the mortar. This is represented in fig. 151. It is the best kind of cover to use in powdering substances which do not become diffused through the air during the process, but some of the particles of

which would, nevertheless, be projected out of the mortar if there were no cover to it. As it merely rests on the top of the mortar, and is not fastened down, it is easily removed and replaced, without loss of time, in transferring the pounded

substance to the sieve. But this cover, although a sufficient security against the loss of coarse particles, will not prevent the escape of light powders which rise from the mortar through open crevices, and remain suspended for some time in the air. In such cases the leather cover represented in fig. 149 is used. It consists of a conical leather bag (*F F*), which is tacked to a circular frame fitting closely on to the top of the mortar. The pestle passes through the top of the bag which is tied to it with a cord, and the frame is fastened down with string on two opposite sides of the mortar.

Fig. 151.



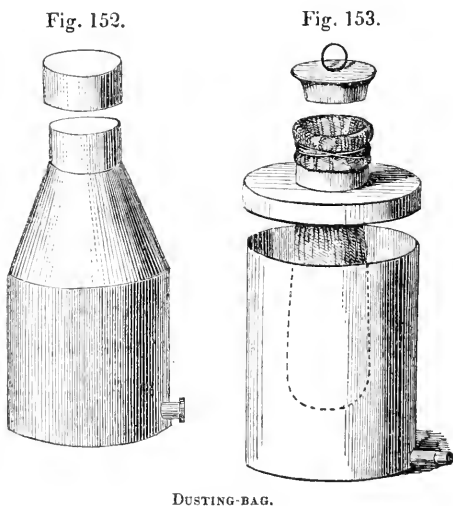
COVER FOR MORTAR.

The substance to be powdered having been previously dried in the drying closet, is pounded in the mortar until well comminuted, and the finer particles are then separated from the coarser by means of the sieve. The sieves used for this purpose are called *drum-sieves*. They consist of three parts,—the sieve, its head or cover, and the bottom or receptacle for the sifted powder; these are fitted together so as to prevent the escape of any of the powder during the process of sifting. When the finer particles of the powder have passed through the sieve, the residue is returned to the mortar and further comminuted; the sifting process is then repeated; and thus, by alternately pounding and sifting, the greater part of the substance is obtained in a state of minute division. There will, however, be a residue ultimately left, which will not pass through the sieve, and which is called *gruff*. This residue is usually kept until more of the same substance is powdered, when it is added to the fresh portion, and again submitted to the process of comminution.

It is sometimes found necessary to dry the substance under operation, and also the sieve, several times during the process, in consequence of the absorption of moisture from the air.

Formerly very fine powders were obtained by the use of what are called *dusting-bags*, and this method appears to be

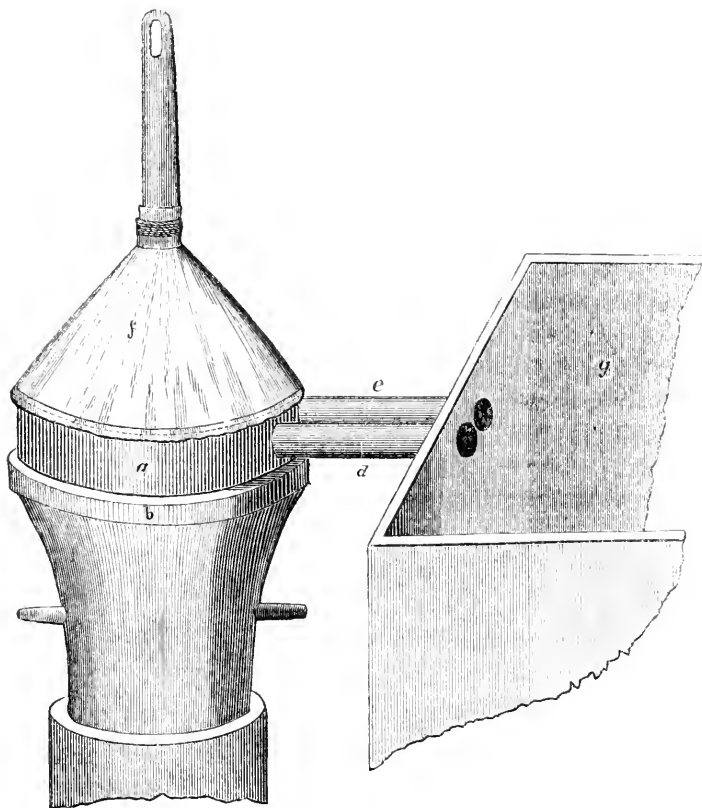
still adopted occasionally in Germany. The dusting-bag is a kind of sieve; it consists of a bag made of lawn or other similar material, which hangs inside a wide-mouthed bottle or a tin canister, to the mouth of which it is secured. The comminuted substance is put into the bag, and the mouth being closed by means of a cover, the apparatus is shaken so that the finer particles of powder



pass through the bag, and are collected in the bottle or canister. Figs. 152 and 153 represent the kind of canisters used for this purpose, and fig. 153 also shows the method of placing the bag.

Dr. Mohr describes an arrangement of apparatus which he has so constructed that the process of comminution and that for the separation of the finer from the coarser particles of powder are carried on simultaneously. This arrangement is represented in fig. 154. It consists of a mortar (*b*), on the top of which a sheet-iron cylinder (*a*) is fitted, and the leather bag (*f*) is tied to the top of this cylinder, as also to the pestle. Two tubes (*d e*) are inserted in the side of the

Fig. 154.



APPARATUS FOR POWDERING DRUGS.

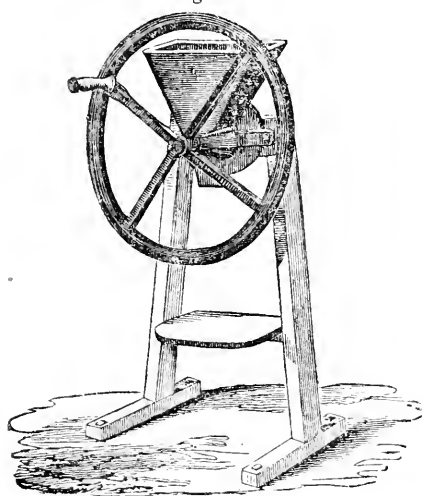
cylinder, and also into a large square box (*g*). There is a valve in each of these tubes, one opening towards the box and the other towards the mortar.

The substance to be powdered is put into the mortar and pounded. As the pestle descends, the leather bag being depressed, forces some

of the air from the interior of the mortar into the box (*g*) through the tube, the valve of which opens in that direction; and as the pestle again ascends the air is drawn back through the other tube. When the substance in the mortar has been reduced to powder the finer particles, being suspended in the air, are carried over with it into the box, where they subside and are collected. The top of the box is covered with a fine cloth, which allows air to pass, but not the powder. This method of operating is said to answer very well in powdering bark and some other substances, the powders of which are light and readily diffused through the air.

[One of the most useful comminuting instruments for pharmaceutical purposes, is Swift's drug-mill, fig. 155, constructed on the

Fig. 155.



SWIFT'S DRUG-MILL.

principle of a coffee-mill, for reducing drugs to coarse powder, so as to fit them for the action of fluids. The uniformity of the division renders the powders yielded by it well fitted for the displacement process.

The grinding surfaces consist of circular iron castings, studded with concentric rows of pyramidal teeth; the apices of the rows of one plate fitting between those of the other, and the channels between the teeth forming radiating lines. The teeth decrease in size towards the circumference;

those at the base of the hopper, near the centre of the moving plate, are large, and hooked like an eagle's bill, so as to catch and draw in the materials placed in the hopper.

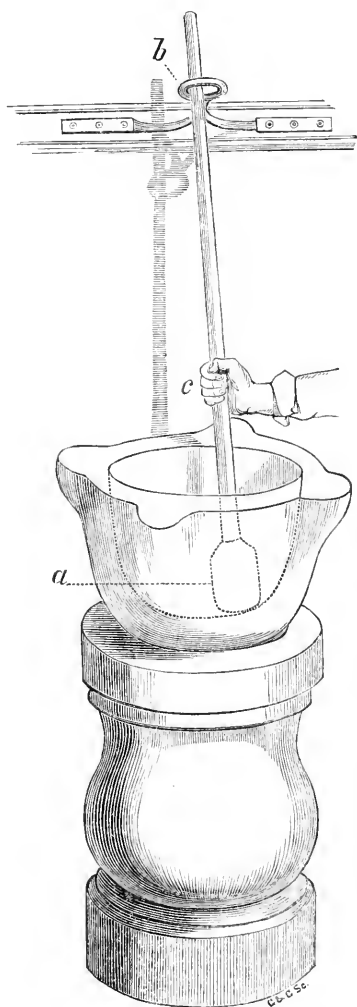
The substances to be ground should be well dried, a precaution which not only renders the process much easier, but prevents the clogging of the teeth, and the liability to contaminate the next article ground. Substances like senega, ipecacuanha, blood-root, &c., which are irritating and troublesome in the mortar, are reduced, by this mill, with ease. The coarseness of the product is varied by a pair of screws pressing on the end of the axle, so as to approximate the plates.

Cream of tartar, Rochelle salts, tartaric acid, etc., are ground advantageously in burr-stone mills. One of these, employed in this city, in which a cone of burr-stone revolves vertically within a conical cavity lined with the same material, is very powerful as a comminuting agent.—W. P.]

Trituration.—The process of trituration, when applied to the pulverization of drugs, is sometimes effected by a pestle and mortar. This, at least, is the usual method of operating when the process is conducted on a small scale. The mortars used in these cases are made either of marble or Wedgwood-ware. Fig. 156 represents a large marble mortar, such as is used for trituration. The pestle (*a*), which is generally made of *lignumvitæ* or other hard wood, but sometimes of marble or stone, has a long handle which passes through a ring (*b*) fixed to the wall at a height of four or five feet above the mortar. The operator holding the pestle at *c*, and, pressing it with greater or less force against the bottom of the mortar, moves it in a circular direction, occasionally enlarging or contracting the extent of the circle, so as to expose the powder more completely to the action of the triturating surfaces. In this way many salts and crystalline and other easily pulverized substances are reduced to powder. The ingredients of compound powders are also mixed by a similar process of trituration.

The largest sized triturating mortars commonly used are made of marble, but the use of this material is by no means unexceptionable.

Fig. 156.



MARBLE MORTAR FOR TRITURATION.

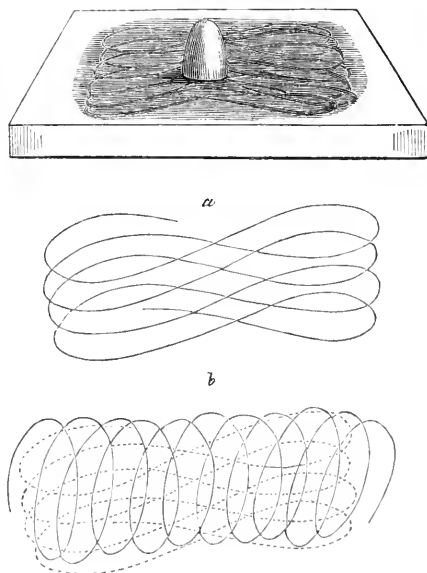
It is easily acted upon by acid salts and other substances which may be put into the mortar; moreover, the surface of the marble is readily abraded by the triturating process, and the substance operated upon would thus become contaminated with calcareous matter.

It appears to be difficult to find a good substitute for marble in the construction of mortars for trituration. Wedgwood-mortars are not made of sufficient magnitude or thickness to be suitable for some of the processes alluded to, and porphyry, which would be quite unobjectionable in other respects, is too expensive for common use. Some pharmaceutical implements made of porphyry, including slabs and mortars, were imported from the continent a few years ago, but they were found to be unsaleable in consequence of their high price. Among them was a triturating mortar of very large size, being twenty-nine inches in diameter, which was purchased by Mr. Bell, of Oxford Street. It has proved to be a most valuable instrument in the laboratory, as it resists the action of most chemical agents, and is hard enough and strong enough to admit of the process of contusion, as well as that of trituration, being effected in it. The price originally asked for this mortar was fifty guineas. It is possible that glass, which is now so advantageously applied to the construction of culinary implements, might be formed into mortars of the requisite size for the process here contemplated. Even dolomite or magnesian limestone would probably be better than marble, and would be inexpensive.

Trituration is sometimes effected with the *porphyry slab and muller* (fig. 157). This method, however, is but rarely adopted for powdering drugs. The process by which substances are thus comminuted is called *porphyritization*. The substance under operation is placed on the slab in coarse powder, and if unacted upon by water, is formed into a thick magma with that liquid. It is then distributed in a thin stratum, and triturated by means of the muller, which, being grasped with the two hands of the operator, is rubbed with some degree of pressure over the surface of the slab. In performing this operation the muller is made to describe, in its course, certain regular curvilinear figures, representing either a figure of eight, as at *a*, or a series of intersecting circles, as at *b*; and these figures are alternated from time to time, so that by changing the direction in which the muller is moved a fresh set of particles may be brought under its action. In this way comminution is effected over an extended surface upon a very thin layer of the triturated substance, and the action is therefore more complete and uniform than that produced by the use of the pestle and mortar.

Trituration over a slab, usually of slate, with a great number of mullers worked in different directions by machinery, has been very successfully applied in the manufacture of blue pill and mercurial ointment.

Fig. 157.

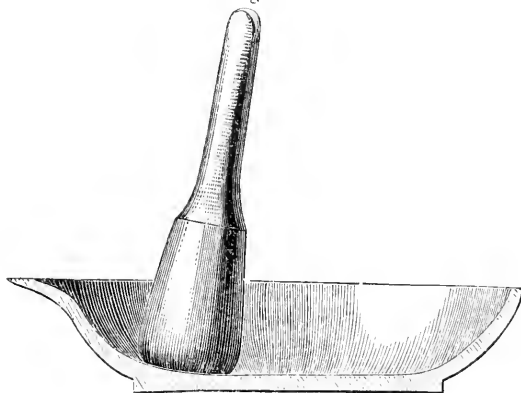


PORPHYRY SLAB AND MULLER.

The process by which substances are reduced to a state of minute division by rubbing them between two hard surfaces when formed into a paste with water, is sometimes called *levigation*, and is thus distinguished from ordinary *trituration*, in which the comminution is effected without the intervention of a liquid.

In Germany, a shallow porcelain vessel is substituted for the porphyry slab, in the leviga-

Fig. 158.



LEVIGATING VESSEL.

tion of substances which are triturated with water. Fig. 158 represents a section of the vessel thus used.

In performing the process of levigation it is necessary to apply some amount of pressure beyond that which the weight of the pestle, as usually constructed, would produce; and this is the most conveniently effected by means of an elastic pole fixed to the ceiling,

as shown in fig. 161. The wooden spring (*c*) is fixed to a beam in the ceiling at *a*; it is also secured by a staple at *b*; and there is a square block of wood attached to it at *d*, with a conical hole in the centre, in which the pointed end of the handle or shaft of the pestle works.

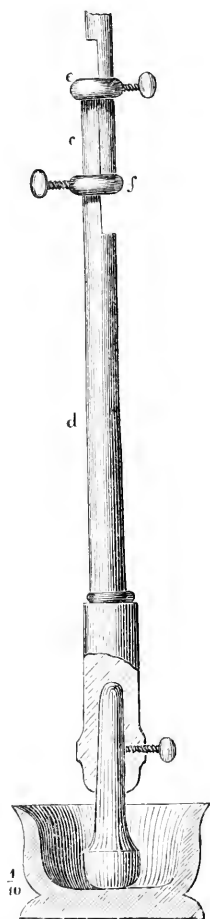
Fig. 159 is a representation, on a larger scale than fig. 161, of the pestle, standing in a levigating vessel, with a view of the end of the spring, and the arrangement by which the length of the shaft of the pestle is lengthened or shortened. The dotted lines (*a*) show the position of the spring in its unstrained state, before applying any pressure. On lengthening the shaft (*d*) by means of the binding screws (*e f*) the spring will be raised to the position of *b*, and the pressure of its elasticity will be imparted to the pestle.

Fig. 160 represents another method of adjusting the length of the shaft of the pestle, and thus regulating the amount of pressure.

Fig. 159.



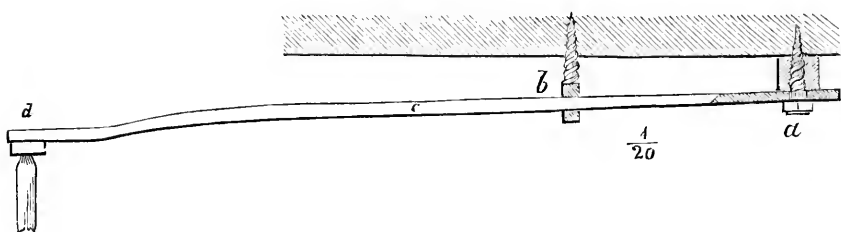
Fig. 160.



SPRING PESTLE FOR LEVIGATION.

Substances which have been prepared in a finely divided state by levigation are sometimes formed into little conical masses while in the

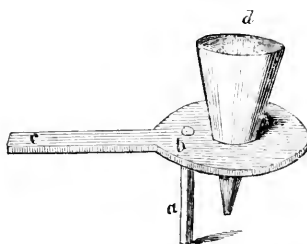
Fig. 161.



SPRING FOR LEVIGATING APPARATUS.

moist state, with the view of facilitating their subsequent desiccation. This is effected by means of a small mould, such as that represented by fig. 162. The mould consists of a hollow metallic cone (*d*), which is fixed in a circular wooden frame (*b*), having a small leg or support (*a*), and a handle (*c*). The apparatus being supported in the position shown in the drawing, the levigated and still moist substance is put into the cone with a knife, and the mould is then inverted over a chalk-stone or other absorbing surface, and the leg (*a*) slightly tapped until the conical mass falls out. The nodules, thus prepared, are subsequently dried by exposure to a current of air. In this way the conical nodules of levigated chalk, bole, and other substances, are made.

Fig. 162.

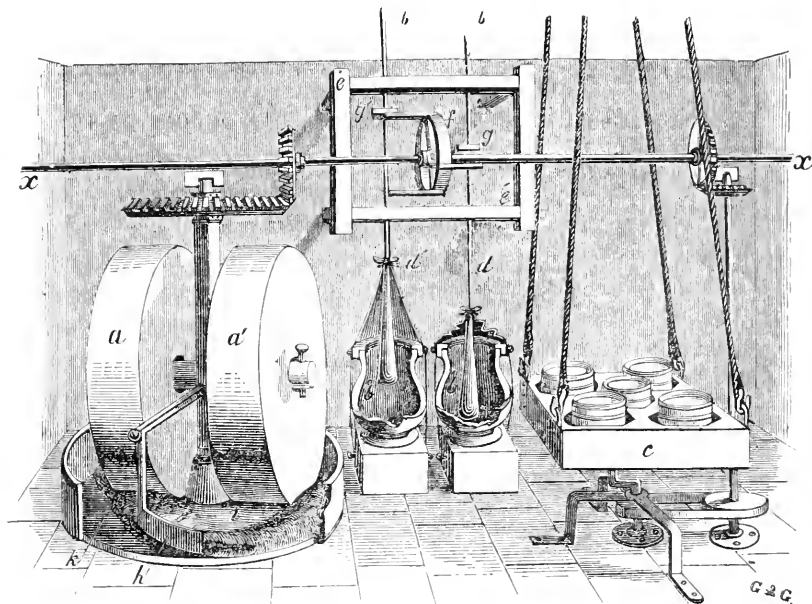


CONICAL MOULD FOR LEVIGATED CHALK, ETC.

There yet remains to be described a method of effecting the comminution of drugs by trituration, which is that principally adopted by drug-grinders. The apparatus employed for this purpose is similar in construction to that which will be described as the drug-mill or pugging-mill, in the Chapter on EVAPORATION. When used for powdering drugs it is generally made with two stone runners, as shown at *a a'*, fig. 163. The runners work on a platform of hard stone or iron, on which the substance to be powdered is placed, and they are put into motion by steam-power, communicated through a revolving shaft (*x x*), which extends across the room. The plough (*h*) gathers the powder which has been scattered by the stone that has passed, and turns it into the path of the approaching stone, as shown at *i* and *k*.

This mill is a most efficient instrument for effecting the comminution of drugs. The runners, which are made of granite or other hard stone, and usually weigh a ton or more, break down or tear asunder the hardest and toughest substances. The disintegration is effected partly by the weight of the stone, and partly by the grinding action produced in consequence of the outer and inner edge of the revolving cylinder (*a*), which are both equal, being made to perform unequal circuits in the same time. Thus, if either of the cylinders were simply

Fig. 163.



APPARATUS FOR DRUG-GRINDING.

a a'. Drug-Mill. *h*. The Plough. *b b'*. Stampers. *e e*. The Guiding-frame for Stampers.
c. Sifting Apparatus.

trundled, without control, it would proceed in a straight line, but being made to describe a circle immediately around the central beam, the outer edge of the cylinder has to travel through a longer path than that assigned to the inner edge: so that every advance onwards, by which the weight or pressure is imposed upon a new surface, is accompanied by a lateral friction caused by the unequal progression of the two edges of the cylinder.

[In some establishments drug-grinding is effected in a large iron mortar-shaped vessel fitted with a tight cover, through the centre of

which a long-handled pestle passes. The substance to be powdered is put in this vessel, then half a dozen iron balls from half a pound to a pound in weight, after which the cover and pestle are replaced. By giving the end of the pestle a rotary motion, it being fixed at the point of passing the cover, the attrition takes place between it and the mortar, as well among the balls which are driven around by the pestle. The same idea is carried out in the revolving barrel and balls used in French powdering establishments. A strong barrel, lined with sheet-iron, revolves on an axis passing through the centre of its heads, and into its interior the drug to be comminuted and a number of iron balls are introduced, the attrition taking place between the balls and the sides of the barrel.—W. P.]

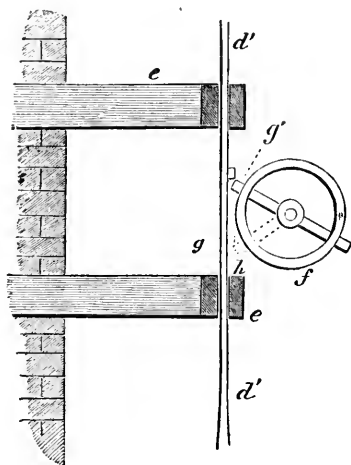
Drug-grinding.—The operations connected with the pulverization of drugs on the large scale, commonly called drug-grinding, present some points of interest even to the retail pharmacist. The implements used by the drug-grinder for effecting comminution are, as already stated, the grinding-mill and the stamper. The former of these is principally used, the stamper, or pestle and mortar, being employed only in some particular cases, where the quantity to be operated upon is small, or where it is important to confine very carefully the dust arising from the process.

A drug-grinding-room usually contains a pair of stones (*a a'*) fig. 163; a set of stampers, such as *b b*, and a sifting apparatus (*c*). These are all worked by the same shaft (*x x*), which extends across the room.

The stampers (*d' d'*), which pass through the guiding-frame (*e e*) are raised by the arms (*g g'*) of the revolving wheel (*f*), as shown in fig. 164.

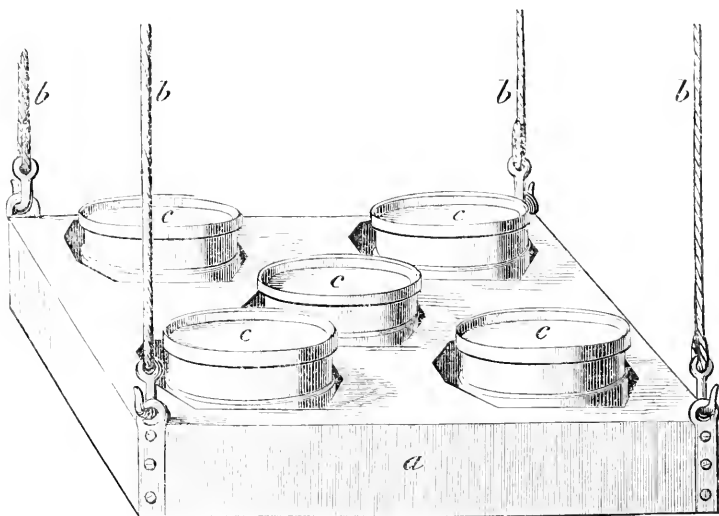
The sifting apparatus consists of a square wooden frame (*a*), fig. 165, in which there are five or six octagon-shaped holes for the reception of the drum-sieves (*e*). This frame is suspended from the ceiling by four ropes or chains (*b*). The frame is put into motion by a spindle (*e*), fig. 166, which works in a square socket in the bottom of the frame, and is turned by an endless strap (*d*). The arrangement by which this is

Fig. 164.



effected is shown in fig. 166. A very irregular and jerking motion is

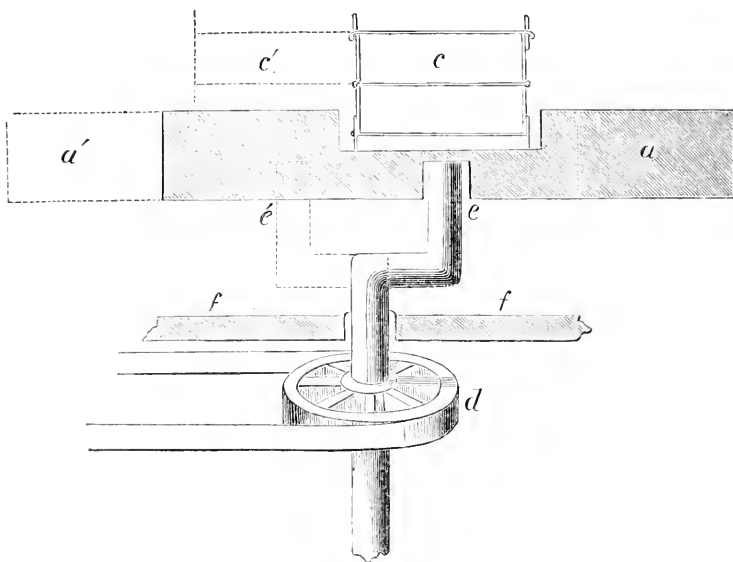
Fig. 165.



SIFTING APPARATUS.

thus imparted to the frame (*a*), and from thence to the sieves (*c*), by

Fig. 166.



SIFTING APPARATUS.

the joint action of the revolving crank and of the ropes by which the

frame is suspended. The sieves employed in the process are the common drum-sieves.

The first operation connected with the grinding of drugs consists in drying them. If they are in large masses, these are cut or broken into small pieces to facilitate the drying process, and also to prepare them for being put under the stones when dry enough to be powdered. The drying is generally effected in a room heated to about 120° , by means of a stove or steam-pipe. The most common method of heating the drying-room appears to be by the use of a cockle, that is, a stove having an outer case or jacket, between which and the fire-case there is a space for the circulation of air. A great many different forms are given to the cockle, which is sometimes made of iron, and sometimes of brick, but it should always be so placed that the fire can be fed from the outside of the room, so that the atmosphere of the room may not be contaminated with smoke or dust. The substances to be dried are spread out on trays of similar construction to those described in connexion with the drying-closet (see chapter on EVAPORATION).

The drying process being completed, the substance is placed on the platform of the mill, in the path of the stones (*a a'*), where it is ground until sufficiently comminuted for the commencement of the next operation, namely, that of sifting it. The two operations of grinding and sifting are then continued simultaneously, the operator transferring a portion of the powder from the mill to one of the drum-sieves (*c*), which latter, with its contents, is put into its appropriate receptacle in the frame of the sifting apparatus, where it is subjected to the requisite succession. The residue, which does not pass through the sieve, is returned to the mill, and a fresh portion of powder taken out to be sifted; and this mode of proceeding is continued without suspending the motion of any part of the machinery, until the process is finished.

[In the larger establishments for powdering, bolting-cylinders are sometimes employed when the powders are manufactured in large quantities. These are constructed like the bolting machines employed in flouring mills. It is well known that ligneous fibre is the portion of drugs most difficult to comminute. It should, therefore, be a practice, never omitted, to mix the whole product of one lot of a drug obtained at different siftings, so that it may possess a uniform activity.—W. P.]

In using the stampers, it is necessary to suspend the pounding or stamping, while the substance under operation is being removed from, and introduced into, the mortar, which somewhat retards the process.

The facility with which drugs are reduced to powder by the means

which have been described, depends in great measure upon the extent to which they are previously dried. If they be not deprived of their hygrometric water to the greatest extent practicable by exposure in the drying-room, it will be difficult, if not impossible, to produce perfectly smooth and impalpable powders, such as are now generally used in medicine. This drying is, of course, accompanied by a loss of weight, arising from the water which is driven off, and which varies considerably in different drugs, and also in different specimens of the same kind of drug. There is always, however, a little moisture again absorbed during the process of grinding. In some cases this re-absorption takes place to a considerable extent, so that it may be necessary to renew the drying before the process is concluded, if the atmosphere of the room be at all damp. This is the case with squills, jalap, rhubarb, aloes, and colocynth.

There are some drugs which, however carefully they may be dried, are, nevertheless, with great difficulty reduced to powder by the ordinary method of proceeding. *Nux vomica*, *St. Ignatius' beans*, and the tuberous roots of the orchis, belong to this class. They are tough and horny, and can hardly be powdered without a particular treatment. The best method of preparing *nux vomica* and *St. Ignatius' beans* for pulverization is, to expose the seeds to the action of steam until they have swelled to about twice their original size, and then to dry them rapidly in the drying-room. The roots of the orchis, which are ground to make saloop powder, should be macerated in cold water until they have become soft, and then dried as in the other case. After being thus treated they are easily powdered.

Some substances cannot be powdered alone; they require the addition of other bodies which facilitate the disintegration. Thus the addition of a few drops of spirit renders the pulverization of camphor easy, although it could not be effected without it. The process, when thus conducted, is sometimes called *pulverization by mediation*.

It is a common practice with drug-grinders to add a small quantity of olive oil or oil of almonds to some drugs during the process of grinding. This is found to facilitate the comminution, and greatly to improve the appearance of the powder.

Agaric is a substance which it is extremely difficult to powder alone, and a method has therefore been proposed for powdering it by mediation. It is cut into small pieces, wetted with mucilage of tragacanth, and then dried, previously to submitting it to the process of grinding. The addition of a foreign body, which the powder retains, cannot, however, be sanctioned, excepting under particular circumstances,

such as the impossibility of otherwise effecting the object. It is stated in some pharmaceutical works that colocynth is powdered by mediation, in the same way as that above described for the pulverization of agaric; but in this case the addition of a foreign body is certainly unnecessary, and I believe that no such addition is made by the drug-grinders in this country.

Phosphorus is powdered by mediation, and this, indeed, is the only way in which it can be obtained in a state of minute division. The best mediatory substance to use is spirit. The phosphorus being put into a bottle with some spirit, a gentle heat is applied, by plunging the bottle into warm water, until the phosphorus melts; the mouth of the bottle is then closed and brisk agitation continued until it has cooled, when the phosphorus will be found to be in a finely-divided state. Water might be substituted for spirit, but does not answer so well.

A method of a somewhat analogous nature to that last described is adopted for powdering some salts which are not easily reduced to powder by trituration. The salts are dissolved in water, and the solution evaporated to dryness whilst constant and active agitation is maintained. This is a very convenient and economical method of obtaining sal ammoniac in powder. It is also adopted for granulating salt of tartar, and tartrate of potash.

Substances, the particles of which readily adhere when submitted to pressure, but which, nevertheless, are not held together by a strong cohesive force, are sometimes powdered *by friction* over a perforated surface. Thus magnesia and other similar substances, are merely rubbed over the surface of a sieve.

[Precipitation is sometimes resorted to as a means of obtaining substances in fine powder. Tartar emetic, when dissolved in water and precipitated by alcohol, is obtained in a state well suited for making the ointment. Precipitated carbonate of lime, now so much used, is another example. Calomel and sulphur are obtained in powder by means of a current of air passing over the surface of the subliming vessels in which they are heated.—W. P.]

Such are the various methods adopted in effecting the pulverization of drugs, and which are applied, according to the requirements of the several cases, to most kinds of solid substances employed in medicine—to some, in order to make them more suitable for administration—to others, in order to fit them for subsequent operations. It is, therefore, an interesting and important subject of inquiry, in connexion with a process of such general use in the preparation of medicines,—

how far is it practicable to preserve the chemical condition of the substances operated upon unaltered, and their medicinal efficacy unimpaired?

The operations connected with the processes of drug-grinding do not seem to be calculated to promote chemical change in the constituents of the powder; for, although the disintegration, by exposing a larger surface to the action of the air, may be somewhat unfavourable to the permanence of the proximate constituents of vegetable substances, yet the complete desiccation which forms part of the process will exercise a conservative influence to probably an equal extent. This, at least, would be the case if the powder, when prepared, be put into close bottles and kept for only a moderate length of time.

The principal, if not the only necessary, cause of deterioration to the product in the process of drug-grinding, is the long-continued application of heat to which the drugs are exposed in the drying-room. There are many substances which cannot be thus dried without having a portion of their active volatile ingredients driven off, as well as the water they contained. The strong smell which fills the drying-room when opium, or myrrh, or cinnamon, are under operation, affords sufficient evidence that some volatile matter besides water is escaping, and that the resulting powders cannot strictly represent the drugs from which they are made. All substances which contain volatile principles must lose a portion of these during the drying process which precedes and sometimes accompanies that of pulverization; and if the efficacy of the medicine depend upon these volatile parts, the product must be injured by the process to which it is submitted. Thus, myrrh, valerian, cardamoms, cinnamon, and spices generally, lose some of their efficacy in being reduced to fine powder.

But a large proportion of our drugs are not subject to deterioration from a loss of volatile constituents; and in these cases, if care be exercised in conducting the process of drying, the powders obtained by the usual method of operating, will possess all the medicinal properties of the crude materials. Thus, rhubarb, jalap, ipecacuanha, colocynth, scammony, gamboge, and many other drugs, are not necessarily injured in the process of powdering.

There are some drugs which not only suffer no injury in being powdered, but which actually contain, when pulverized, a larger proportion of the active constituents than were present in the crude unpowdered substance. This arises from the circumstance that the less active parts are separated and rejected during the process. Thus, for instance, the powder of ipecacuanha, if properly prepared, contains

more of the emetic principle than the root from which it is made. The principle upon which the emetic property of ipecacuanha depends, exists chiefly in the cortical part of the root, and as this is the most easily pulverizable, it passes first through the sieve, while the less active ligneous part, being more tough, remains to the last, and may be, and generally is, rejected as gruffs.

Besides the loss of water and other volatile constituents, which are driven off in the drying-room, there is also, necessarily, a dissipation and loss, to a certain extent, of solid particles of powder, which are diffused through the atmosphere of the room in which the pulverization is conducted, or which adhere to the apparatus.

With these exceptions the product, including the gruffs or unsifted part, ought to be identical with the substance it represents; that is to say, should consist of the same particles, and no others, in the same chemical condition as they existed in previously to the process of powdering.

If no active constituents be lost in the drying process, the strength of the powder will be greater than that of the crude drug, to the extent of the quantity of water and inactive matter which have been separated and rejected. It would be very desirable to ascertain what the average increase of strength is in those drugs which suffer no deterioration in the process of powdering; and also what is the exact nature of the deterioration necessarily sustained by drugs, such as myrrh, ginger, cardamoms, and cascarilla, which contain, and must therefore lose, active volatile constituents.

Next to the preservation of the medicinal efficacy of the drug, the most important object for attainment is uniformity of strength in the product. What security has the physician that a grain of opium, or ten grains of jalap, obtained from a particular source, shall be equivalent to the same quantities of those substances obtained elsewhere?

There are several causes which tend to affect the uniformity of the strength of those medicines which consist of parts or crude products of plants. In the first place, these drugs, in their natural or original state, are not uniform in composition and properties. Different specimens of cinchona bark yield very different proportions of the alkaloid, upon which the efficacy of the drug depends; other drugs differ to an equal extent,—in fact, what drug can be mentioned of which there are not good and bad specimens in the market? The practical knowledge and experience of the druggist are called into requisition in selecting the good from the bad, and thus two classes, at least, are formed. It must be admitted, however, that the criterions of excellence

usually adopted in these cases are often founded upon qualities of an extrinsic character, which have no definite relation to medicinal properties.

There are other causes which affect the uniformity of strength and properties of drugs in their more advanced states of preparation.

That drugs are sometimes adulterated is a notorious fact. That the practice of adulteration has prevailed to an extent greatly prejudicial to the advancement of the science of medicine, and discreditable to the medical legislation of the country, admits not of a doubt. But a great and progressive improvement has certainly taken place within the last few years, and there is, at the present time, an evident desire among wholesale and retail druggists, to discourage and suppress the sale of bad drugs.

We may discard as unworthy of notice the exaggerated statements which have been published with reference to the wholesale substitution of fabricated powders for genuine drugs. Such cases, if they ever existed, must have been isolated and extraordinary exceptions to the practice generally pursued. There is reason to believe, however, that absolute identity of composition between the powders used in medicine, and the drugs they represent, is not always maintained to the greatest practicable extent; and among the causes tending to this effect, there is probably none more influential than the conventional practice of the trade, in reference to the allowance for loss of product during the process of drug-grinding.

It has already been stated that the loss of weight which drugs undergo in the process of grinding is occasioned by the evaporation of water and other volatile constituents in the drying-room, and by the waste from dissipation in the form of dust, and from adhesion to the apparatus in the grinding-room. It must be obvious that the amount of loss thus sustained will not be uniform; it will vary according to the nature of the substance under operation, and even with substances of the same nature the loss will depend upon the quantity operated upon at a time and their state of dryness when sent to the mill. Some drugs are frequently met with in commerce in a perfectly moist state, such as opium, aloes, scammony, and jalap. The loss of weight in drying these drugs must of course be considerably greater than that which occurs with other less moist specimens, or with substances such as rhubarb, ipecacuanha, or bark, which are never met with in a moist state. Now there is in this variable condition of drugs as to dryness, a source of disagreement between the druggist and the drug-grinder, which probably has led to the adoption

of a practice that has prevailed throughout the trade, with one or two recent exceptions, of making a uniform allowance for loss of weight in grinding, whatever the nature or quality of the drug might be.

The rule which for many years has been adopted among the London drug-grinders, is to allow four pounds on every hundred-weight of the substance ground for loss in the process. Thus, if a hundred-weight (112 lbs.) of rhubarb be sent to the drug-grinders, 108 lbs. of powder, including the gruffs, are returned. It matters not what condition the rhubarb may be in, the drug-grinder is expected to produce 108 lbs. of powder from the hundred-weight of raw material. The same allowance is also made, unless otherwise agreed between the parties, for all other drugs which require drying previously to their being powdered. In some cases the practice appears to be to receive 116 lbs. of the undried drug, and to return 112 lbs. of dry powder. This is called the four per cent. system; four pounds being the allowance for loss upon every hundred-weight of substance powdered. Some substances, however, such as cream of tartar and sulphuret of antimony, do not require to be dried before being powdered, and the allowance for loss on these substances is only two per cent.

There has, until quite recently, been only one exception to the adoption, to a greater or less extent, of this, which is called the percentage or four per cent. system, by the drug-grinders of London; and so completely does the system appear to have been established by long custom, that although several attempts have been made to relinquish it, yet there are still some druggists who contend that the specified allowance is a fair average of the loss necessarily occurring in the process of drug-grinding.

I am indebted to Messrs. S. and G. Allen, for a statement extracted from their books, showing the loss of weight sustained in powdering drugs at their mills. Every drug powdered at this establishment is weighed when received at the mill; and the ground products, consisting of fine powder and gruffs, are again weighed before being returned to the druggist. These weights are all entered in their books, a separate account being kept for each kind of drug; so that by taking an average of the results upon large quantities, consisting of a great number of specimens received from different druggists, a near approach to a correct estimate is no doubt attained.

The first column of figures in the following table represents the whole quantity of the specified drug which has been ground at several different periods; the second column indicates the greatest amount of loss on any one specimen; the third column indicates the smallest

amount of loss on any specimen; and the last column gives the average upon the whole.

Name of drug.	Total weight.	Greatest loss per cwt. (112 lbs.)	Smallest loss per cwt. (112 lbs.)	Average loss per cwt. (112 lbs.)
	lbs.	lbs. oz.	lbs. oz.	lbs. oz.
Aloes, Barbadoes	379	9 12	0 7	5 12
“ Hepatic	997	16 8	3 8	9 6
“ Socotrine	882	12 0	4 0	9 4
Calumba root	733	12 0	1 12	6 6
Canella alba	460	12 0	1 0	9 0
Cantharides	1006	3 0	—	1 8
Cardamoms	348	9 8	2 10	5 12
Cascarilla bark	794	8 14	2 0	6 0
Cinchona bark, pale . .	1547	7 8	4 0	6 6
“ yellow	1039	11 0	2 8	6 2
Colocynth	1034	11 8	3 8	6 8
Cubebs	1551	2 10	—	1 10
Dragon’s blood	1004	13 0	1 4	5 12
Elecampane	1585	16 0	2 12	9 3
Fœnugreek	2593	13 0	2 0	7 10
Gamboge	1009	6 8	1 0	2 12
Gentian root	5368	16 0	4 0	9 4
Ginger, Jamaica	8046	12 8	6 0	7 10
Gum Arabic	11,215	12 0	4 0	8 0
Ipecacuanha	2579	7 0	1 4	5 3
Jalap	9446	15 8	5 0	8 12
Liquorice	1255	12 0	—	6 3
Myrrh	2762	16 0	3 12	8 6
Opium	505	18 0	6 0	14 14
Orris root	3625	10 12	4 3	6 12
Rhatany	81	8 0	2 10	6 0
Rhubarb, English . . .	1346	12 0	3 0	7 13
“ Indian	5777	7 0	2 0	6 0
“ Turkey	2018	8 4	3 0	5 12
Sarsaparilla, Jamaica .	689	14 0	1 12	10 1
Scammony	1161	13 0	2 8	7 4
Seeds, Anise	2839	16 0	1 0	5 12
“ Caraway	1569	13 8	2 8	8 12
“ Coriander	1063	16 14	1 4	5 9
“ Cummin	1142	12 0	1 4	5 4
Senna	606	11 8	3 8	6 6
Squill	974	15 0	8 0	12 8
Tormentilla root . . .	231	12 8	2 0	6 12
Tragacanth	2077	13 12	6 12	8 4
Turmeric	5663	8 0	1 8	4 0
White Hellebore . . .	5533	10 12	2 2	6 4
Valerian root	279	16 8	4 0	8 8

It appears from this table that the average loss in powdering drugs is more than four per cent. in nearly all cases, and that in some it is considerably more. Now, can it be reasonably supposed that, in these cases, the drug-grinder will supply good rhubarb or jalap, gentian or ginger, for the water which has been imbibed in a damp

warehouse or cellar? He is required to make up a certain quantity of powder, evidently more than the crude drug produces, but how is he to do it? Does he keep a stock from which to supply the deficiencies of all the drugs he grinds, and go to market and purchase more when his stock is exhausted; or is there some magical power in his mill?

A drug-grinder's mill (*a a*, fig. 163) is a very different thing from the pestle and mortar of the druggist, although they are both employed for the same purpose. The druggist, when he has used the pestle and mortar, cleans it preparatory for the next operation, by washing it out with water. The drug-grinder also requires to clean his mill. Rhubarb must not be ground after aloes, nor ginger after jalap, without previously well cleaning the ponderous stones and other parts of the apparatus. But how shall this be done? A drug-mill cannot be cleaned by washing it with water,—if for no other reason, it would be objectionable on account of its making the room and apparatus damp, which are required to be perfectly dry. Instead of water, sawdust is used for cleaning the drug-mill. After grinding any drug, in order to remove the adhering particles from the mill, sawdust is ground until the mill is rendered sweet and clean.

Sawdust, then, is indispensable at a drug-mill, as necessary as water is in a druggist's shop, and if the druggist sends damp jalap, containing fifteen per cent. of water, to be ground, and requires dry powder to be returned, with only four per cent. of deduction for loss, he adopts a conventional method of asking for some of the rinsing of the mill,—a veritable “powder of post.”

The four per cent. system cannot fail to induce a reduction in the strength of powdered drugs. If this reduction tended to equalize the strength of different specimens, there might be some excuse for it; but the effect of the system must obviously be to cause a reduction, in an inverse ratio to the previous strength of the drugs, so that the weakest and worst drugs will be most diluted. But this objection, which applies to the very principle of the system, is not the most serious objection to which it is subject. It sanctions the practice of admixture, and affords facilities for those who are so disposed, to pursue a ruinous competition in price at the sacrifice of quality.

There are two causes, which, I believe, principally tend to frustrate the efforts of those who are endeavouring to put a stop to the adulteration of drugs; one is, the sale of cheap medicines by grocers and others not educated as pharmacutists, who are unable to distinguish the good from the bad, or indifferent as to which they sell;

and the other is, the continuance of the four per cent. system in connexion with drug-grinding,—a system which has no claim for support, save the long-established usage of the trade. It should be the enlightened policy of an educated body of pharmacutists to afford a fair remuneration for honest industry, and this being secured, both drug-gist and drug-grinder would rejoice to be relieved from the hereditary trammels of the present system.

GRANULATION OF METALS.

There are some metals, such as zinc and tin, which, previously to their application for certain purposes, are reduced to a granular condition. The process by which this effected is called *granulation*.

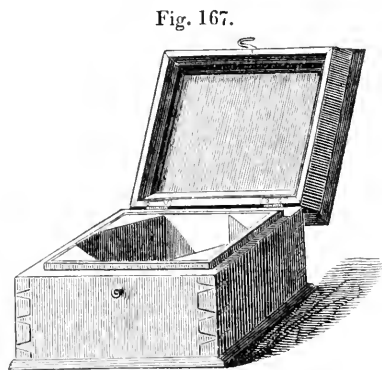
The granulation of zinc is effected in two different ways, one being intended for the reduction of the metal to a coarse, and the other to a more minute state of division.

Coarsely granulated zinc is prepared by melting the metal in an iron ladle, and pouring it in a thin and intermitting stream into a large pan filled with water. Little conical nodules are thus obtained, which present the metal in a convenient form and condition for acting upon it with acids. In performing the process it is necessary to be careful that the melted metal be not too rapidly poured into the water, and that there is a sufficient quantity of water in the pan to prevent the projection of hot metal or water over the operator.

Finely granulated zinc is prepared by rubbing the melted metal in an iron mortar, and continuing the process until it has become solid. In its ordinary condition, as obtained by casting it in blocks, zinc is rather brittle, but sufficiently tough to resist any efforts at powdering it, as antimony is powdered, by mere contusion in a mortar. If heated to about 300° F., it becomes malleable and ductile, and if submitted to the process of rolling while at this temperature, it not only readily admits of extension into sheets, but afterwards retains its malleability when it has cooled. At a temperature of 400° or a little higher, it entirely loses its ductile property, and becomes so brittle that it can be rubbed to powder in a mortar with the greatest facility. It melts at 773° F., so that its melting point is many degrees above that at which it becomes most brittle. The object contemplated in the above process for powdering or granulating it, is, by beginning the trituration at an elevated temperature, to insure its passing, as it cools, through the state most favourable to its disintegration. It is desirable,

however, that the cooling should not take place very rapidly, and especially that the metal should remain for some minutes at a temperature between 400° and 500° . The mortar in which the trituration is effected should, therefore, be thick, and it should be made hot before the introduction of the zinc, by putting ignited charcoal into it, or by some other means. After rubbing the metal to powder in the mortar, the finer particles are to be separated from the coarser by passing them through a sieve.

The granulation of tin may be effected in a similar manner to that last described for granulating zinc. Tin is very brittle at a temperature a little below its melting point, and at that temperature it may be easily rubbed to powder. There is, however, a still easier and more expeditious method of granulating tin, which consists in pouring the melted metal into a strong wooden box, such as fig. 167, and, after securing down the closely-fitting lid, shaking the box until the metal has become hard. On opening the box the tin will be found to be in small grains.



GRANULATING-BOX.

Many pounds of tin may be granulated in this way in a few minutes. The grains will not be all of one size, but they may be sorted either by the use of sieves, or by elutriation.

It is important, in the foregoing processes, that no more heat than is necessary should be applied. Much metal is often wasted by allowing it to remain in the fire after it has melted, when oxidation rapidly proceeds.

Zinc, at an elevated temperature, undergoes combustion, and the oxide thus formed diffuses itself in a cloud through the air. Tin is also rapidly oxidized when exposed to the air in a melted state. But in the case of tin, the application of more heat than is necessary for its fusion is also objectionable on account of its causing the carbonization of the granulating-box. It is customary to guard against this effect by rubbing some chalk over the inner surface of the box. This tends to protect the wood, but it causes the granulated tin to be contaminated with chalk, which has to be subsequently removed by washing the metal with diluted acetic acid.

Iron is granulated by the mechanic's file, which supplies the filings so frequently employed in the laboratory. But iron filings obtained from this source are very impure, and it is necessary to submit them to some process of purification before they are used for any pharmaceutical preparations. They are generally contaminated with grease which is used in the process of filing, and they also contain a considerable quantity of oxide.

The best method of purifying iron filings is to triturate them in a Wedgwood-ware mortar with solution of caustic potash, pouring off the solution from time to time, while the oxide remains suspended in it, and repeating the trituration with fresh potash, or, after the second or third addition, with pure water; thus removing impurities partly by solution, and partly by elutriation. The filings will speedily become bright and clean with this treatment, and when the oxide has been entirely removed,—the elutriation being always effected with pure water towards the latter part of the process,—they are to be drained for a few minutes, then washed with a little spirit, and dried quickly over a stove.

[Iron is best obtained in fine powder by the process of reduction by hydrogen, as noticed in the chapter on the absorption of gases.—W. P.]

Gold and silver are sometimes reduced to powder or small grains, and the processes by which the disintegration of these metals is effected are peculiar.

The powder either of gold or of silver may be prepared by rubbing the metal, in the form of leaf, on the porphyry slab with some honey until it is reduced to a finely-divided state, and then dissolving out the honey with water. Sulphate of potash or cream of tartar is sometimes substituted for the honey, or used with it, in which case hot water is employed as a more ready solvent of the salt. If required in larger quantity, gold may be obtained in powder by first forming an amalgam with it, and then distilling off the mercury. Silver may also be treated in the same way. A convenient method of obtaining pure silver in the form of powder or minute grains is, to reduce chloride of silver by boiling it with solution of caustic potash and a little honey.

Some salts, such as salt of tartar, are said to be granulated when they are obtained in small, irregular crystals, by a particular treatment, which has been already described in connexion with the pulverization of drugs.

ELUTRIATION.

The process of elutriation has been already alluded to as a method by which the finer particles of a powder are separated from the coarser. The process consists in diffusing the powder through water, allowing the larger and heavier particles to subside, and then decanting the liquor, with the smaller particles still held in suspension, into another vessel, and allowing them to subside there. It is obvious that the process can only be applied to those substances which are not dissolved or chemically acted upon by water. It is used for separating impurities from chalk. It is also applied in the separation or sorting of the different sized grains of emery. The process is a very convenient one for dividing a powder consisting of different sized grains into several parts, each containing particles of tolerably uniform dimensions. On mixing the powder in its original state with the water, the largest particles subside the soonest, and the longer the mixture is allowed to rest the more uniformly small will be the particles remaining in suspension. If the liquor containing these be now decanted, and more water added to the powder that remains, another set of particles less finely comminuted will be obtained by allowing rather a shorter time for subsidence. The process may thus be repeated for an indefinite number of times, according to the kind of separation required.

Powdered or granulated tin is one of the substances which is frequently sorted by elutriation. Iron-filings are purified by this process.

[NOTE. The mode of using the apparatus (fig. 162), as described at page 157, is not that generally employed. The apex of the inverted cone should be slightly truncated, so as to leave a small opening. When used, the operator takes hold of the handle *c* with his right hand, fills the cone with the pasty substance to be made into conical masses, and then by striking a succession of gentle blows on the absorbent surface with the foot *a*, each shock causes a portion of the paste to fall out, and in striking the surface it takes a conical form. The foot *a*, is struck in a different spot each time, and the blows are graduated in such a manner as to make the cones nearly of equal size.—W. P.]

CHAPTER VI.

DECANTATION AND WASHING. THE SYPHON. THE SEPARATION OF IMMISCIBLE FLUIDS.

DECANTATION AND WASHING.

THE term *decantation* is applied in pharmacy to the act of pouring a liquid from a precipitate or sediment contained in the same vessel. Cases constantly occur in the laboratory in which this operation is required to be performed. Thus, in the process of elutriation, the liquor containing a part of the powder originally diffused through it, is decanted from that part of the powder which has subsided.

[By the term *washing* is understood the removal of soluble from insoluble matter, by agitating the mixed solids with water or other menstruum, allowing the insoluble matter to settle, and then drawing off the supernatant fluid by the processes of decantation ; or it may be effected by pouring the mixed solids and fluids on a filter, and dissolving out the soluble matter by lixiviation. The latter method will be noticed in describing the operations of filtration and precipitation. The theory of washing by decantation may be thus explained. If a solution containing 161 grains of sulphate of soda, be mixed with another solution containing 131 grains of nitrate of baryta, 120 grains of insoluble sulphate of baryta will precipitate, and 100 grains of soluble nitrate of soda will remain in solution. If now the mixture be diluted with water till it measures 100 fluid ounces, it follows that each fluid ounce of the washing fluid contains one grain of nitrate of soda. If after settling, 95 fluid ounces be decanted and the vessel filled to the same height as before, it is obvious that 95 grains have been removed, and the remaining five grains are distributed in the 100 fluid ounces of water last added. If all is drawn off now but five ounces, it follows that there only remains a quarter of a grain, which is almost entirely removed in the subsequent drainings.—W. P.]

The mere pouring of a liquid from one vessel to another, however simple it may appear, is not always an easy operation, especially to the uninitiated. The form of the vessel, the extent to which the liquid fills it, and the nature of the liquid, materially influence the facility with which the operation is performed. The difficulty is also enhanced when the precipitate is light and easily caused to diffuse itself through the supernatant liquor by a slight agitation.

The objects to be attained in performing this operation are, to pour or otherwise remove the liquid from the containing vessel without spilling any of it, and without disturbing the sediment. If the vessel containing the liquid be provided with a suitable lip or spout, there may be no difficulty in pouring the contents into another vessel without any loss; but, in the laboratory, decantation has to be performed with vessels of all kinds, and with some the operation is not an easy one.

In pouring from a vessel, such as the dish (*a*, fig. 168), a rod placed

Fig. 168.



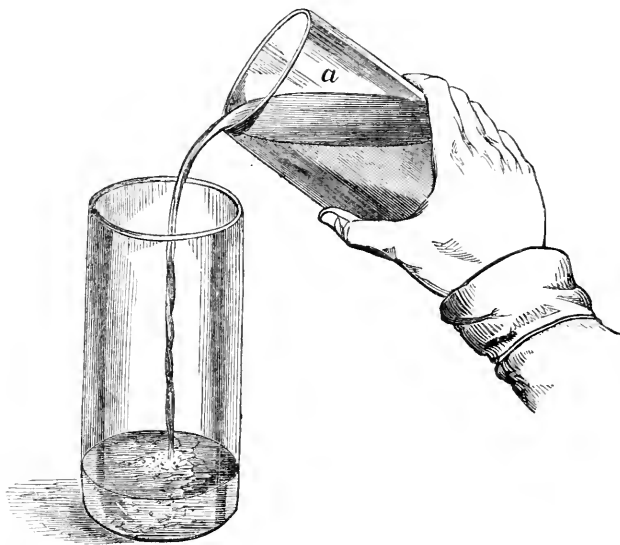
DECANTATION WITH A GUIDING-ROD.

as shown in the drawing, facilitates the safe transference of the liquid by guiding it to its destination. In this case, the adhesive

attraction between the rod and the liquid prevents the latter from flowing in any other direction than that represented, although if the rod were not used, a portion of the liquid would run down on the outside of the dish, and form a separate stream distinct from that in which the principal part of the liquid flowed. The guiding-rod will prevent this splitting of the current, so long as the quantity of liquid flowing be not too great in proportion to the size of the rod, and provided that it flow over the edge of the vessel, at a certain inclination, in a cylindrical stream, and not in a wide current or sheet of liquid. If the circumference of the vessel be large, it will be difficult, if not impossible, to pour with the guiding-rod; and this will especially be the case if, in addition, the sides of the vessel be perpendicular, and the quantity of liquid contained in it such as nearly to fill it.

When the form of the vessel or the quantity of liquid which it contains, precludes the possibility of pouring over the edge without spilling, merely with the aid of the guiding-rod, the object may still be attained, by rubbing a little grease over the part at which it is in-

Fig. 169.



DECANTATION OVER A GREASED RIM.

tended that the liquid should flow. This prevents adhesion of the liquid to the surface of the vessel, and the liquid being therefore subject only to the force of cohesion among its own particles, forms a more contracted channel, and runs in a more cylindrical stream than

would otherwise be the case. Fig. 169 is intended to illustrate the effect of applying a little grease to the edge of the vessel (*a*) from which a liquid is being poured.

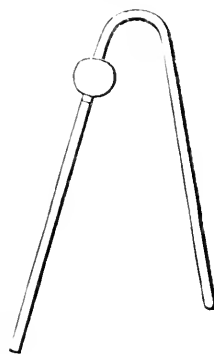
But cases constantly occur in which decantation cannot be effected by pouring the liquid over the edge of the vessel, whatever means be adopted for facilitating the operation. Moreover, it is always difficult, and sometimes impossible, to incline the position of the vessel to the required extent, without disturbing the precipitate. In these cases decantation is effected with a syphon.

The *syphon* is a tube bent as represented in fig. 170. It consists essentially of two limbs, which communicate at the bend, while the lower extremities are open and unconnected. The two limbs are usually of unequal lengths. If the short limb of the syphon be plunged into a vessel filled with some liquid, which is made to fill the interior of the tube by sucking air from the outer extremity, or in any other way, the liquid will discharge itself from the end of the longer limb, and will continue to flow as long as this end of the tube is below the level of the liquid in which the other end is immersed.

The uninterrupted efflux is caused by the unequal pressure of the columns of liquid in the two limbs of the syphon. The effect may be thus explained:—

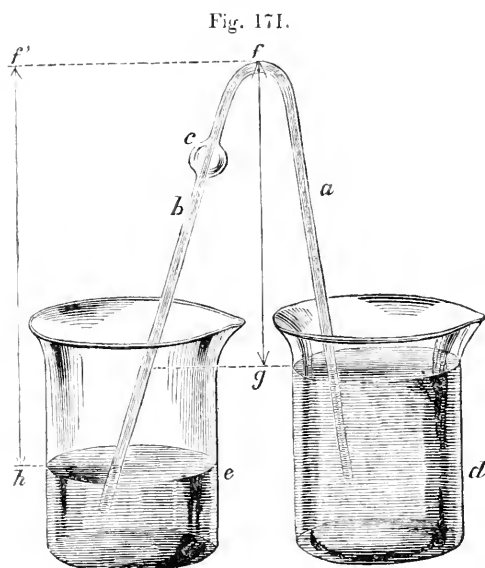
If the syphon (*a b*, fig. 171) be filled with water, and the open extremities plunged into two vessels (*d e*) containing the same liquid, there will be in the contents of each limb of the syphon two pressures exerted,—a pressure downwards, caused by the gravitating force of the liquid,—and a pressure upwards, caused by the gravitating force of the atmosphere exerted upon the surface of the liquid in the vessels, and communicated in accordance with the law of hydrostatics. These two forces, the one antagonistic to the other, would be similarly exerted if the two limbs of the syphon did not communicate at the bend. The force upwards, which is equal to the weight of a column of air having the circumference of the column of water in the tube and the height of the entire atmosphere, will be sensibly the same in both limbs of the syphon. The force downwards, which is proportionate to the perpendicular height of the column of water in the tube above the level of the water in the vessel into which the tube

Fig. 170.



SYPHON.

dips, will be greater in the long limb than in the short one. In the short limb the pressure of the atmosphere is opposed to the weight of a column of water ($f g$). In the long limb the pressure of the atmosphere is opposed to the weight of a column of water ($f' h$). In either case the atmospheric pressure will preponderate over that of



SYPHON.

the liquid so long as the height of the column of liquid (water) is less than thirty-three or thirty-four feet; and the water is supported in the tube by the excess of the upward over the downward pressure. The excess or balance in favour of the upward pressure is obviously greatest in the short limb, and therefore, if the two limbs communicate at the bend (f) the upward pressure in the short limb will over-

come the upward pressure in the long limb, and a current will be determined towards the open end of the long limb, where the liquid will be discharged. This current will continue until ($f g$) and ($f' h$) are equal, when the upward pressures in the two limbs will exactly counterbalance each other, and the current will then cease. The effect would be the same, if the limb (f) of the syphon did not dip into the liquid contained in the vessel (c). The pressure of the atmosphere would then be exerted directly upon the liquid contained in the tube, instead of being communicated through that contained in the vessel.

The length of either limb of the syphon is estimated from the surface of the liquid into which its end is immersed, the part of the tube which is beneath the surface of the liquid having no influence on the result. It is not, therefore, necessary that the two limbs of the instrument should be of unequal length, as the immersed limb might be shortened by dipping it deeper into the liquid; it is, however, found practically convenient to have one limb longer than the other, so that by always immersing the short limb, and keeping the instrument in

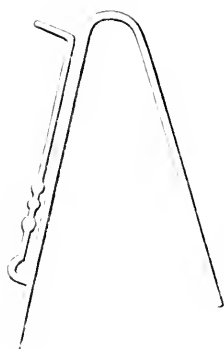
an upright position, the operator may be certain that the external limb contains the longest column of liquid, and that the current will therefore be continuous.

The bulb represented in the upper part of the long limb of the syphon in figs. 170 and 171, is not essential, and is not taken into account in the foregoing description, but will be alluded to hereafter.

In using a plain syphon, consisting simply of a bent tube, such as fig. 170, without the bulb, it is necessary to get it filled with the liquid to be decanted, either by withdrawing the air with the mouth from one extremity while the other extremity is immersed in the liquid, or by inverting the tube, pouring the liquid in at one of the open ends until both limbs are full, then stopping the two orifices with a finger of each hand, and immersing the end of one of the limbs while the liquid is allowed to run from the other. The former of these methods is inelegant, and with some liquids is impracticable. The latter method is also impracticable in some cases, as for instance, where the liquid is of a strongly caustic character, into which the finger could not be safely introduced, or where it has to be decanted from a vessel the mouth of which would not admit the hand.

Two modifications have been made in the form of the syphon with the view of remedying the above defects. One of these modifications consists in having a bulb blown in the long limb of the instrument, as shown in fig. 170. In using this form of syphon, the tube is inverted and liquid poured in until it is entirely full, the extremity of the long limb is closed by placing a finger over it, and the instrument being restored to its proper position, the contents of the short limb are allowed to run out; the end of the short limb is now immersed in the liquid to be decanted, and on removing the finger from the other end, the fluid descending from the bulb by its own weight, draws the liquid from the vessel into the short limb until a current is established throughout, as shown in fig. 171, the bulb remaining partly empty. It is necessary, in this case, that the capacity of the bulb shall be rather more than equal to that of the short limb of the syphon, so that the air originally present in the tube (*a*) may be retained in the bulb while the current of liquid passes through its centre. The other modification is represented in fig. 172. It consists in having a small tube attached to the long limb near to its lower end, and extending upwards to the bend, where it is turned outwards. This tube is used for withdrawing the air with the mouth while the end of the short limb is immersed in the liquid to be decanted, and a finger is placed over the orifice of the long limb. In withdrawing the air, the syphon

Fig. 172.



SYPHON.

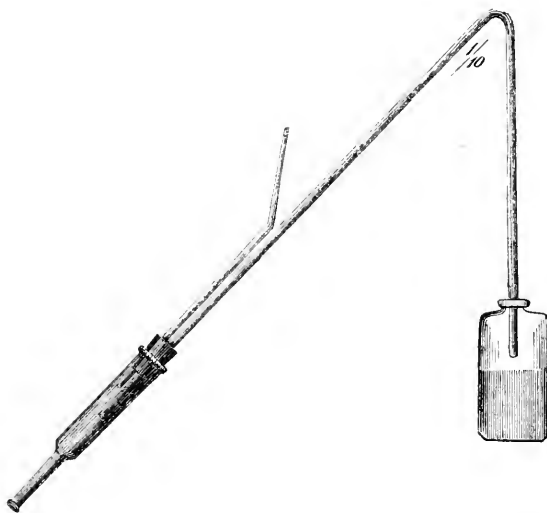
should be turned until the long limb is nearly horizontal, the end to which the suction-tube is attached being the most elevated part, so that the air may be entirely removed from the two limbs of the instrument before the liquid enters the suction-tube. When the syphon has been thus filled with liquid it is to be restored to its vertical position before the finger is withdrawn from the orifice of the long limb.

Dr. Mohr has described the following ingenious method of constructing a syphon with a suction-tube.

The bottom is cut off from an eau de Cologne bottle of the long cylindrical kind.

This may be done by making a scratch with a file and then applying the point of an incandescent piece of charcoal, in a manner to be hereafter described. The sharp edges of the newly-cut surface are to be removed with a file, so that the open end of the

Fig. 173.



SYPHON.

bottle may receive a cork. This being done, a tube of suitable length for the syphon is to be bent to an angle of about forty-five degrees; and the end of the longest limb of this tube, and also another tube, of smaller diameter, to be used as a suction-tube, are inserted by means of a perforated cork into the bottle, as represented in fig. 173.

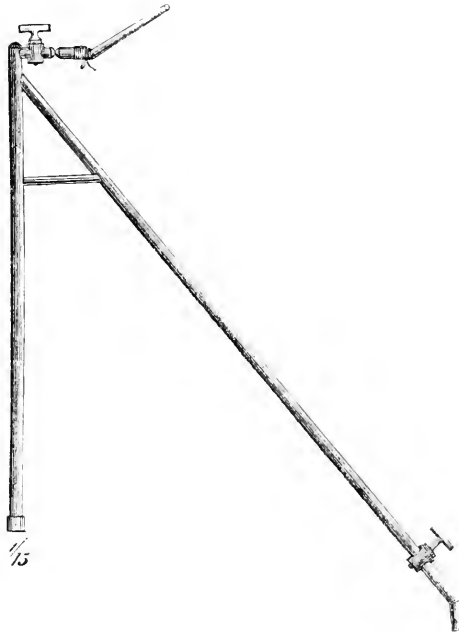
This forms a very convenient syphon. The end of the short limb being plunged into the liquid to be decanted, and the other extremity closed by applying a finger to it, the air is removed with the mouth applied to the suction-tube until the liquid has partly filled the eau de

Cologne bottle. On removing the finger the current will be established.

When the syphon is made of a metallic tube, the suction-tube may be conveniently attached to the upper part of it, as in fig. 174. In this case there are two stop-cocks used,—one at the end of the long limb, and the other in the suction-tube. The latter of these is necessary, but the former might be dispensed with if the length of the syphon be such as to admit of the orifice of the long limb being closed with the finger while the mouth is applied to the suction-tube. In using this instrument, the air is drawn out until the liquid rises into the suction-tube.

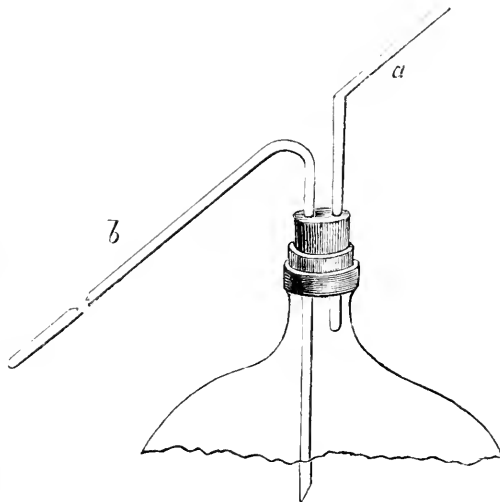
In decanting a liquid from a bottle or carboy, the arrangement represented in fig. 175, may be conveniently adopted. A plain syphon-tube (*b*), and also a tube (*a*), are made to pass through a perforated cork which fits the mouth of the bottle, and while the cork is thus inserted, air is blown from the mouth

Fig. 174.



SYPHON.

Fig. 175.

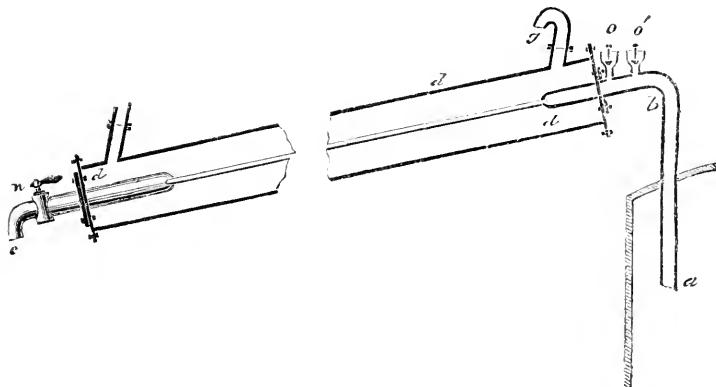


SYPHON.

through the tube *a*, until the liquid is forced into the syphon, and the latter being once charged, the current will be continuous.

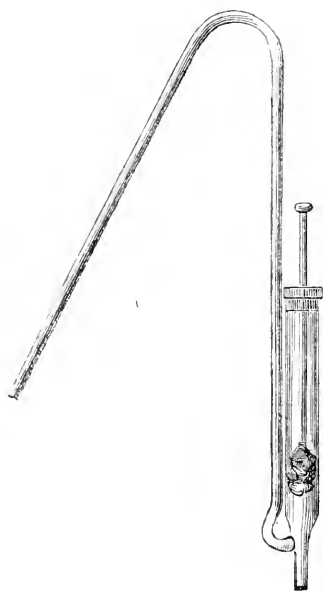
[The platina refrigerating syphon, used in the manufacture of sulphuric acid, may be instanced. Its object is to draw off the highly heated concentrated acid from the still, at once into the earboys. It is on the principle of Liebig's condenser. The syphon *a, b, c*, (fig. 176,) is let into a wide tube *d d*, which is supplied with a current of cold

Fig. 176.



water, which enters below, and passes out through *g'*. To fill the syphon,

Fig. 177.



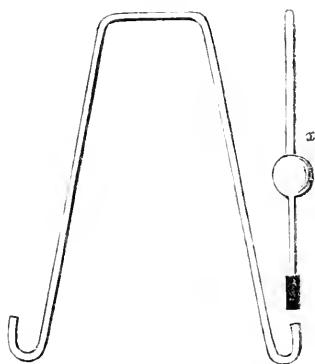
NEGRETTI'S SYPHON.

at *o o'*, until the long limb is filled, when *o o'* are closed, *n* is opened, and the syphon comes into play. Negretti's syphon (fig. 177) for acid liquids, has a syringe instead of the lateral tube. Its mode of use is obvious.—W. P.]

In the forms of syphon hitherto described, the current, when established, continues without interruption until the short limb of the instrument ceases to be immersed in the liquid, or until the descending column of liquid in the tube ceases to be longer than the ascending column; and the liquid then discharges itself from the syphon, which latter requires to be re-filled before it can be again put into operation. This necessity for re-filling the syphon each time it is used is sometimes found to be a great inconvenience, to obviate which

the form of instrument represented in fig. 178, has been adopted. In this the two limbs are of equal length, and the extremity of each limb is turned up, so that, when the tube is filled with liquid, it will retain the charge, and may be used for an unlimited number of times without the necessity of re-filling it. The bulbed tube (*x*) is used for charging the syphon, the Indian-rubber connector attached to its end being placed over the end of one of the limbs of the syphon, and the air sucked out by the mouth, while the other end is immersed in a liquid. When thus filled it may be removed from the liquid, and if the two ends be kept in a horizontal plane, the liquid will not run out from either of them; but if one of the limbs be immersed in a liquid until the orifice of the tube is beneath the surface, the liquid will begin to flow at the opposite extremity, and will continue to do so until the surface of the liquid from which decantation is being effected sinks to a level with the orifice of the efflux tube. The current will then cease, but the syphon will not discharge its liquid contents. On lowering the immersed end, the current will again commence, and it may be thus renewed and stopped at pleasure; or the syphon may be transferred to another vessel, and used there, without requiring to be re-filled.

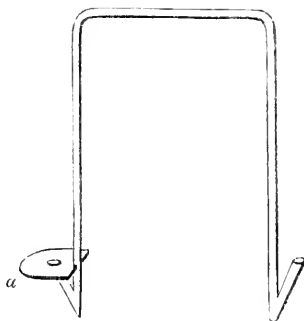
Fig. 178.



SYPHON.

This is a most convenient syphon for effecting decantation, especially in those cases in which the precipitate is easily disturbed, or in which it is desirable to suspend and renew the decantation several times during a process. If the instrument be made of metal it will be found advantageous to have it constructed like fig. 179. The only essential difference in this modification of the instrument is, that a metallic plate (*a*) is fixed to one end of the tube in such a way as to prevent the liquid entering the tube at this end from forming a current upwards, and

Fig. 179.



SYPHON.

thus disturbing the precipitate. It will be obvious that the liquid in approaching the orifice of the tube must pass either in a descending or horizontal direction.

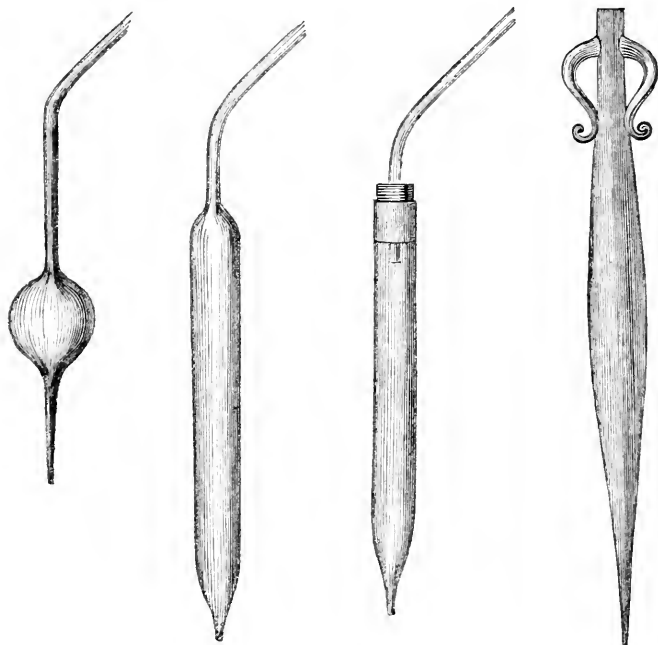
Pipettes are sometimes used for withdrawing small quantities of liquids from the surface of precipitates, or from places from which it would be difficult otherwise to remove them. The most common form of the pipette is that represented in fig. 180. It consists of a glass tube in which a bulb is blown, and the lower extremity of the tube is drawn to a capillary opening, while the upper end is bent to an oblique angle. The point of the instrument being placed in contact with the liquid to be removed, the latter is sucked into the bulb by applying the mouth to the other end of the tube. Fig. 181 is another form of the apparatus, which is made by uniting a piece of narrow tubing to

Fig. 180.

Fig. 181.

Fig. 182.

Fig. 183.



PIPETTES.

one of larger diameter, the lower extremity of the latter being drawn to a capillary bore. Both these kinds of pipette are made by the aid

of the blowpipe, and some skill and experience are required in making them. Fig. 182 represents a pipette, which any operator may make in a few minutes without possessing any experience in glass-blowing. It consists of a piece of tube about three quarters of an inch in diameter and six or seven inches long, which is drawn to a capillary bore at one end, and rounded off in the flame of the lamp at the other end, where a piece of narrow tubing, bent as represented, is inserted through a cork. Figs. 184 and 185 represent other forms of the apparatus.

That shown in fig. 184 is a glass tube, to the end of which an Indian-rubber bottle is attached. In using this, some of the air is forced out by compressing the Indian-rubber, and the point of the tube being then applied to the liquid, the Indian-rubber is allowed to resume its original form, in doing which it sucks up the liquid. Fig. 185 is made from the end of a tube-funnel, over the mouth of which a piece of sheet Indian-rubber is tied.

The glass syringe (fig. 33) might be used instead of either of these pipettes, and for most purposes to which the pipette is applied, it forms a convenient substitute. Sometimes, however, the pipette is used, not merely for removing liquids in the manner above described, but for taking a specimen, sometimes a measured specimen, from a vessel into which it is plunged. The instrument used for this purpose, of which fig. 183 is a common form, is called the *plunging-syphon*. It is immersed into the liquid and allowed to remain there until full, when the opening at the top is closed with the thumb, and the instrument, with its contents, thus removed, and the latter subsequently discharged by allowing the air to enter at the top.

[Besides the separation of fluids from solids, the pharmacist has frequently to separate immiscible liquids from each other, as ether from water, oils from water, chloroform from water, solution of tannin from ether, &c. When the quantity of the supernatant liquid is large, the decantation can be effected to a great extent by the syphon; but it generally happens that the whole of one or other of the fluids is wanted. In these cases resort is had to the separating-funnel, fig. 186. The best of these come from France and Germany. They consist of a strong glass funnel, with a conical orifice made transversely through the neck, which is increased in diameter at the point. A glass stopper,

Fig. 184.

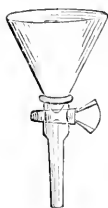


Fig. 185.



PIPETTES.

Fig. 186.



SEPARATING-FUNNEL.

perforated so as to answer for a stop-cock, is ground into this orifice. When used, the cock is closed, the mixed fluids poured in the funnel, and a plate of glass laid on the top to prevent evaporation, until the line of separation is complete; the stopper is then gradually opened, and the inferior fluid suffered to run out, decreasing the volume of the escaping fluid as it approaches the last.

Fig. 187 represents a vessel for separating volatile liquids from heavier ones, as ether from water, and which prevents loss by evaporation.

Dr. Mitchell has proposed fig. 189 as a cheap substitute for the separating funnel, which is a common funnel with a long glass or cork stopper.

When the quantity of one of the fluids is very small, the vessel, fig. 188, is very appropriate, as in heavy volatile oils. By inclining

Fig. 187.



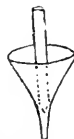
SEPARATOR.

Fig. 188.



SEPARATOR.

Fig. 189.

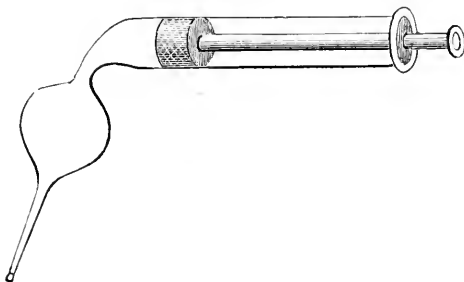


MITCHELL'S SEPARATOR.

the vessel towards the smaller limb, the heavier liquid runs out, drop by drop, from the small orifice.

The little instrument, fig. 190, will be found extremely useful in

Fig. 190.



PIPETTE FOR BROMINE, ETC.

bottling bromine, which is usually kept covered with water. By inserting the long stem of the pipette through the supernatant water, into the bromine, the bulb may be filled by drawing out the piston, when its contents may be transferred to a bottle, previously balanced, and the weight arranged, by

pushing back the piston. This instrument will do equally well for filling vials with oil of roses, and creasote.—W. P.]

CHAPTER VII.

FILTRATION. CLARIFICATION. DECOLORATION.

FILTRATION.

The process of filtration consists in the separation of liquids from substances held by them in suspension, by causing the former to pass through the pores of media which are impervious to the latter. When the solid matter to be removed is a powder which subsides on standing, this is called a *precipitate*, and the liquid separated by filtration is called the *filtrate*. In some cases, filtration is adopted merely for the purpose of rendering turbid liquids clear and transparent, the substances collected on the filter being rejected; in other cases, the object of the process is to collect and preserve the substance which remains on the filter, while the liquid is thrown away; in other instances again, the preservation of both precipitate and filtrate is desired. The materials employed as filtering media, when prepared for use, are called *filters*. These materials are of different kinds, some being organic, such as cloths of linen, cotton, or wool, and paper made of these materials, while others are inorganic, such as sand, pounded glass, asbestos, rock crystal, and charcoal.

Filtering media may, therefore, be divided into two classes, the *organic* and the *inorganic*. The organic media may, again, be divided into those which are of *vegetable*, and those which are of *animal* origin. Besides these distinctions, there is another frequently made, although not always admitted, which is founded on the greater or lesser porousness of the filtering material. Thus, cloth filters are more porous, and offer less obstruction to the passage of any solid particles, than paper filters. Cloth filters, therefore, are generally used in those cases where the solid particles to be removed are not

very finely divided, or where their complete separation is not an object of much importance, while, at the same time, rapid filtration is required. The process thus conducted is sometimes called *straining*, but it differs not essentially from those processes which, being conducted with less porous media, are, in such cases, distinguished as *filtering*.

The substances used as filtering media are:—

Woollen cloth or flannel, which may be of different degrees of thickness and of closeness of texture.

Calico, or other fabric of cotton. There is a material of this kind called *swans-down*, which is used in some cases where fine straining is required.

Linen, or other fabric of flax or hemp.

Filtering paper, of which there are a great many different kinds, but they may all be classed under two heads:—

1. Filtering paper made from cotton or linen rags. This constitutes the thinner and whiter kinds of filtering paper.

2. Filtering paper made from woollen materials. This constitutes the thicker and coarser kinds of filtering paper. It is more porous than the other, and is used for rapid filtration.

There is often some difficulty experienced in getting filtering paper of good quality. It should be easily permeated by the liquids to be filtered, without allowing any solid particles to pass through. It should present a tolerably smooth surface, so that any precipitate collected on it, might be easily removed, and not absorbed into the pores. It should also be strong enough to support the weight of the substance filtered, when placed in a funnel, without breaking. Moreover, it should contain nothing that is soluble in the liquids to be filtered. [Some otherwise excellent filtering paper is valueless for filtering acid solutions, owing to its containing oxide of iron in sufficient quantity to colour these liquids.—W. P.]

Sand.—This should be rather large-grained, and perfectly free from organic matter. It should be purified by washing it with diluted hydrochloric acid, and subsequently with water.

Powdered glass, consisting of common wine-bottle glass, reduced to coarse powder in an iron mortar, sorted by the use of sieves of different degrees of fineness, and then washed with diluted acid and water.

Powdered rock crystal, prepared in the same way as the glass, from chippings formed in cutting spectacle glasses, or from other fragments

of rock crystal. It is preferable to either sand or glass, being less readily acted on by the liquids in the filtration of which it is used. It should be prepared ready for use, reduced to different degrees of comminution, and each kind kept separately.

Asbestos, in the fibrous state, which has been purified by heating it to redness, and then washing it with diluted acid and water.

Animal charcoal, in rough grains, resembling very coarse gunpowder. This is made on the large scale by manufacturers who supply the sugar refiners.

These substances cannot be indiscriminately used in all processes of filtration. It is necessary to make a selection of a suitable material in each process, and some judgment is required in determining what kind of filter is best adapted for the substance under operation.

Woollen cloth is suitable for filtering a great number of substances employed in medicine. The filters used for syrups and for many aqueous decoctions and expressed vegetable juices, are made of this material. This is also the proper material to employ for straining plasters and ointments, or any substances of an oily nature.

Woollen material, whether in the form of cloth, such as flannel, or in that of paper, is inapplicable for the filtration of alkaline solutions, which exert a solvent action on the wool.

Linen and cotton cloths, and *paper made of these materials*, are used in a great variety of cases. They may be employed for the filtration of alkaline solutions, especially linen, which answers the purpose best. Linen or cotton cloths are also generally used for collecting and washing precipitates, where the quantities operated on are considerable. The paper of this kind is perhaps most suitable for the filtration of alcoholic and ethereal solutions. Tinctures, however, are frequently filtered through the coarse paper made from woollen materials.

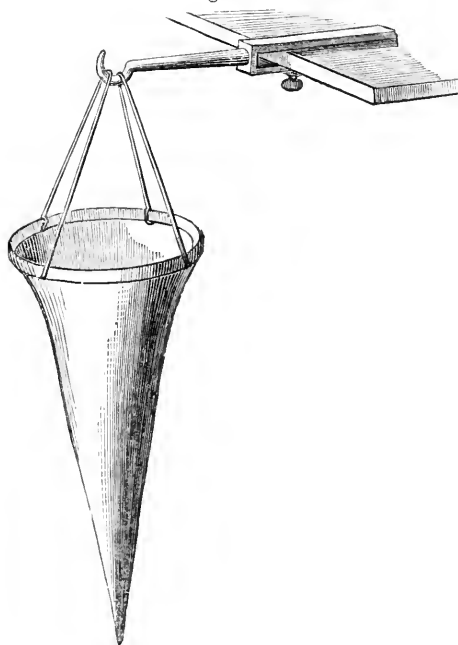
Sand, Powdered glass, Rock crystal, and *Asbestos*, are employed in the filtration of strong alkaline or acid solutions, which would exercise a chemical action on organic filtering media.

Animal charcoal is used in those cases only, where, in addition to the removal of solid particles, it is desired to deprive the liquid of certain constituents, held in solution, which give to it colour or smell.

The method of constructing a filter, and the arrangements adopted in using it, must depend on the nature of the filtering medium used, and on the particular object contemplated in the process to which it is applied.

Cloth filters are, in general, either made in the form of a conical bag,

Fig. 191.



CONICAL FILTER-BAG.

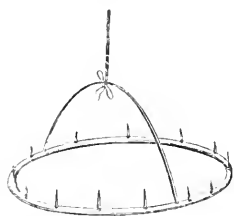
called the filter-bag, sometimes, also, called Hippocrates' sleeve, or they are constructed by loosely attaching the material to a square frame.

The *filter-bag*, or *Hippocrates' sleeve* (fig. 191), is the most useful kind of filter for pharmaceutical purposes. It may be made of flannel, cotton, or linen, which is formed into a conical bag, with a wide hem around the top, into which a hoop of whale-bone, wood, or wire, is put, to keep the mouth of the bag distended. When used, it is suspended by strings from any suitable support, as shown in the

drawing, a vessel being placed beneath it, to receive the filtered liquor.

The principal inconvenience experienced with reference to this filter, consists in the difficulty of cleansing it by washing, while the hoop remains attached to it.

Fig. 192.



This inconvenience may be obviated, if the hoop be of wire, by having an opening in the hem to admit of its removal and reintroduction; or, instead of a hem, the bag may have strings by which to attach it to the hoop. In some cases a metallic ring (fig. 192) is used, which is furnished with a number of spikes, over which the bag is temporarily fixed.

Liquids generally filter with great facility through this bag; indeed, there is no kind of filter that I am acquainted with, through which liquids, that are filtered with difficulty, pass more readily than they do

through this, if a proper selection be made of the material of which the bag is made.

The other form of cloth filter usually adopted, is represented in fig. 193. The cloth is attached by means of nails to the top of the square frame in such a manner that, on pouring the substance to be filtered on to it, the surface of the filter forms a concavity for the reception of the liquid.

This form of filter is convenient, and is generally adopted where the object of the process is to collect and wash a precipitate. In such case a glass rod or stick is advantageously employed to stir the precipitate and break down any masses into which the particles may have aggregated, while the process of washing is continued. Liquids do not pass through this filter so readily as they do through the conical bag, nor is the filtered liquid obtained by it so clear. Its use, therefore, is principally confined to the washing of bulky precipitates. When the precipitate has been sufficiently washed, it is allowed to drain as long as any liquid continues to drop from it, and then, the nails by which the filter is secured to the frame being removed, the ends of the cloth are gathered together in the hand of the operator, so as to squeeze the precipitate into a globular mass, and press out a further portion of liquid from it. A string is now tied round the filter to retain it in the form which has been given to it, and it may be hung by this string in any suitable place to dry.

[Instead of the nails in fig. 193, it is more convenient to have permanent pointed spikes or hooks, inclining outwards, that will readily pierce the cloth, and hold it in its place, by simply stretching it loosely across the frame, and forcing the hooks through its edges at the proper distances. When the washing or filtering is completed, the operator can gather up the edges of the cloth without assistance, and without the necessity of withdrawing the nails, as is requisite in that figured, if the precipitate is to be pressed.—W. P.]

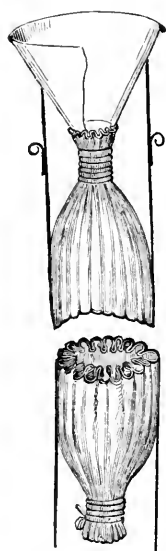
Fig. 193.



FRAME-FILTER.

Taylor's filter, fig. 194, is sometimes used where large quantities of liquid are operated upon, as, for instance, in the filtration of oils, and of syrups in the process of sugar refining. It is not commonly employed in pharmaceutical laboratories, but there are some cases in which it might, perhaps, be used with advantage. The filter is usually made of twilled cotton, which is sewn so as to form a cylinder open

Fig. 194.



TAYLOR'S FILTER.

at both ends, ten or twelve inches in diameter, and six or eight feet or more in length. It is gathered up into plaits and securely tied with a strong cord at the bottom, as represented in the drawing. The top is also gathered into plaits, and these are tied around the neck of a funnel, the lower end of which should have a rim to prevent the bag when heavily laden from slipping off. The filter, thus arranged, is covered with a case just large enough to receive it, which may be made of tin-plate, or of coarse canvass. If a tin-plate case be employed, the funnel will rest on its upper rim, which will thus form a support for the bag; and the whole apparatus may be suspended from the ceiling by cords attached to hooks on the outside of the case.

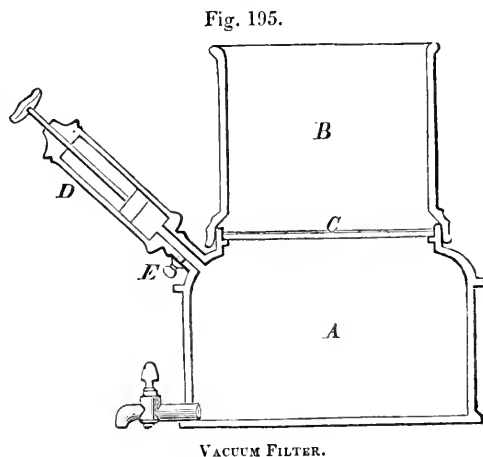
These filters, as used by sugar refiners and other operators on the large scale, have a small funnel-shaped tube inserted in the mouth of the bag, which tube is screwed into the bottom of a large box or trough, capable of thus receiving a great number of such filters, all of which are simultaneously supplied with liquid from the trough.

The advantages resulting from the use of these filters are ascribed to the following causes:—

In the first place, the metallic case prevents evaporation and loss of heat, consequently the liquid retains the fluidity imparted to it by heat for a long time; secondly, the outer case prevents the filter-bag from expanding to its full diameter, and therefore a given quantity of liquid forms a longer column than would otherwise be the case, so that the hydrostatic pressure is increased; finally, there is a large surface of filtering medium with which the liquid is in contact, and as any deposit from the liquid collects at the bottom of the bag, there is but little obstruction offered to the filtration from the accumulation of solid particles over the surface of the filter.

It not unfrequently happens, in pharmaceutical processes, that much difficulty is experienced in the filtration of liquids, some of which, especially if they be thick and mucilaginous, will not pass through the filter. Hence, it has been a desideratum to discover a method of facilitating filtration in such cases, and the *vacuum filter* was represented to be capable of fulfilling this object.

Fig. 195 represents the *vacuum filter*. The vessel A is furnished with a stop-cock, near the bottom, and an exhausting syringe (D) is attached to the upper part of it. A strong perforated disk rests on a ledge within the mouth of the vessel, and forms a mechanical support for the cloth or other filtering medium which is stretched over its surface, and extending to the outside of the rim, is secured in its place by the cylinder (B), the bottom of which fits over it, and forms a water-tight joint. The apparatus, thus connected, consists of two compartments, A and B, with the filtering material forming a diaphragm (C) between them. The liquid to be filtered is to be poured into B, and air removed from A by means of the syringe. The liquid is thus made to bear the pressure of the external atmosphere, which forces it through the filter into the vessel below.



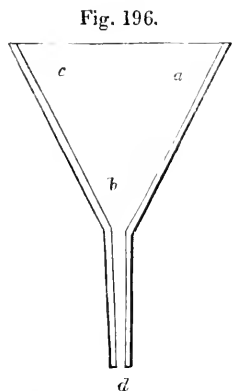
The advantages that were anticipated from the use of this filter have not been fully realized, for although it expedites the filtration of substances which pass with tolerable facility, but not very rapidly, through a common filter, yet it has been found to afford little or no advantage in the filtration of liquids which will not pass through a common filter. When these latter are put into the vacuum filter, and the lower chamber is exhausted, the pressure of the atmosphere, instead of forcing the liquid through the filter, causes minute bubbles of air to pass through the liquid and thus enter the exhausted chamber.

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Paper filters are employed for all the most delicate operations of filtering. They effect a more complete separation of solid particles from the liquids operated upon than is commonly effected by cloth

filters, the pores of the paper being generally more minute than those of cloth. The paper used for filtering is made expressly for the purpose, and is called *filtering paper*. A filter made of this material is never used for more than one operation. It is too fragile to admit of its being purified by washing, after having been once used, and the small cost of the material renders its frequent renewal a matter of little consideration. The necessity for taking a new filter for every process, constitutes, indeed, one of the advantages resulting from the use of paper filters, as it insures the absence of impurities from any previous process. It is important, however, to make a selection of paper suitable for the purpose to which it is applied.

The paper filter, when used, is generally placed in a funnel, which forms a convenient support for it. The funnels thus employed are made of glass or of earthenware; they should have the form represented in fig. 196, the sides (*a*, *b*, and *c*, *b*,) being straight, and the line (*a*, *b*, *d*) forming an angle at *b*. In a section, as shown in the drawing, the lines (*a*, *b*, *c*, and *a*, *c*, *b*) should form angles of 60° , making an equilateral triangle. This form will be found best adapted for the reception of the filter as usually constructed.

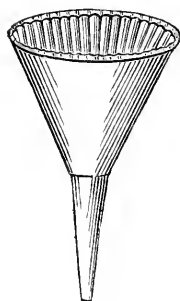


WELL-FORMED FUNNEL.

The funnel may be supported by placing it with the tube inserted into the mouth of a bottle, on the lip of which the funnel rests, while the bottle receives the filtered liquor; or the funnel may rest on the ring of a retort-stand, or other support independent of the vessel into which the liquid is received. Sometimes a perforated shelf or stand is used, as shown at page 34, fig. 22, such arrangement being made expressly for the reception of funnels of different sizes when employed in the process of filtration. If a bottle be made the support for the funnel, it will be necessary to insure free means of escape for the air contained within it as the liquid enters. This is sometimes conveniently provided, when the tube of the funnel fits tightly into the mouth of the bottle, by putting a small piece of folded paper between them, on one side.

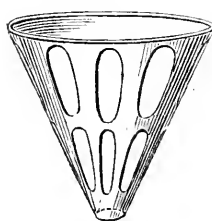
[The best funnels for use in the shop are those of Berlin ware, fig. 197, with the interior either fluted or ribbed, which prevents the sides of the filter from coming in contact with those of the funnel, and permits the filtered liquid to descend without impediment. The porcelain filter support, fig. 198, is used occasionally, and offers but slight opposition to the passage of the liquid.—W. P.]

Fig. 197.



PORCELAIN FUNNEL.

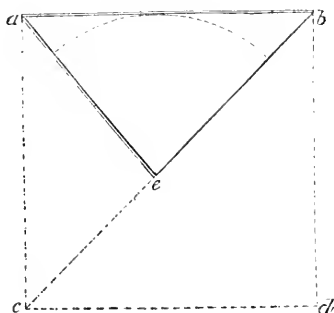
Fig. 198.



FILTER SUPPORT.

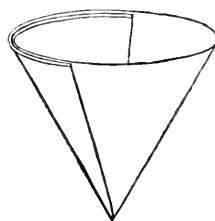
Several different methods are adopted of folding the paper for the construction of filters. The most simple kind of filter is that called the *plain filter*, which is represented in figs. 199 and 200. A square piece of paper (a, b, c, d) is folded, first in the direction (b, c), the point (d) being placed over a . Then the point (c) is placed over b , and a fold made in the direction (a, c). The corners (a and b) are cut off with a pair of scissors, as marked by the dotted line, so as to give the proper form to the filter when opened for use. It may be otherwise made, with a similar result, by folding the paper twice in opposite directions, so as to bring the four corners together, and form a square, one-fourth the original size of the paper. In either case, the paper, when folded as described, will consist of four layers, and in

Fig. 199.



PLAIN FILTER.

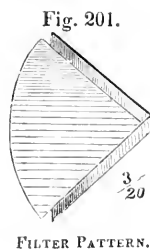
Fig. 200.



opening it for use, as shown in fig. 200, the filter, on one side, will have three layers of paper, and on the other side only one layer.

Dr. Mohr recommends the use of the instrument (fig. 201) for

guiding the scissors in cutting off the corners of the paper. This instrument consists of a quadrant made of tin-plate, the straight sides of which have a rim turned up to the height of about a quarter of an inch. The folded papers are put into this, and a flat piece of tin-plate of the same form is placed over them; the outer edge of the paper is then cut to the figure of the quadrant.



The filter when placed in a funnel such as fig. 198, will fit closely to the sides of the latter, especially when a liquid is introduced into it, and the adhesion which thus takes place obstructs the passage of the liquid, and greatly retards the process. To obviate this effect several means have been recommended. The funnels which are made of Wedgwood's ware are generally grooved on the inner surface, with the view of providing channels through which the liquid may run; but these grooves are seldom of any use, not being deep enough to be efficient. With a similar object, and with better success, glass rods are sometimes placed between the filter and the funnel. There is also a method sometimes practised of slightly modifying the form of the filter so as to obviate, to a certain extent, the evil alluded to. This method consists in rolling one side of the filter as shown in fig. 202, thus making a sort of paper tube, which forms a channel for the liquid to run through. In making this alteration in the filter, its general figure might at the same time be changed to suit the angle of the funnel, if this should be more or less acute than 60° . Figs. 203 and 204 illustrate the way in which this is done, by turning the edge of the paper over to a greater extent at one end than at the other.

Fig. 202.

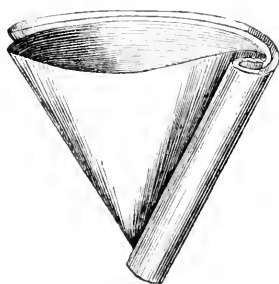


Fig. 203.

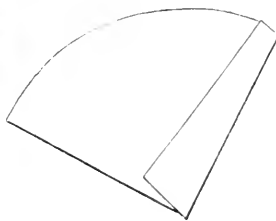
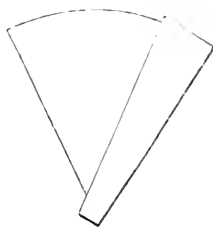


Fig. 204.



MODIFICATION OF PLAIN FILTER.

The most effectual method, however, of obviating the obstruction to the process of filtration resulting from the adhesion of the filter to the

surface of the funnel, consists in the use of the *plaited filter*. This is made in the following manner:—A square piece of paper (a, b, c, d ,

Fig. 205.

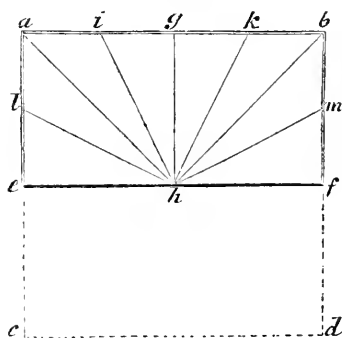
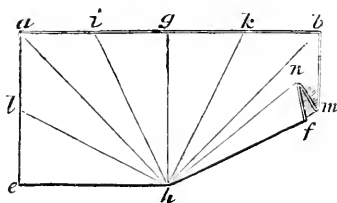


Fig. 206.



PLAITED FILTER.

fig. 205) is folded in the line (e, f) the edge (c, d) being placed over (a, b). This doubled sheet is then creased as represented in the drawing. In the first place, the crease (g, h) is produced by laying bf over ae and pressing the thumb nail, or any hard surface, over the folded edge, so as to produce a sharp crease. Then placing f over g the crease (b, h) is formed; in like manner the crease (a, h) is formed by laying e over g , and by similar means the intermediate creases (l, m, i, k). These creases are all in one direction, forming seven receding angles, and in making them it is desirable not to bring the creases quite to the point (h), but to leave about half an inch or less through which they do not pass, otherwise the frequent foldings of the paper at this point would so weaken the texture as to cause it to break with the weight of the liquid introduced into the filter. In the next place an equal number of creases are to be made in the opposite direction, dividing each of the eight sections, represented in the upper part of fig. 205, in half. In doing this the edge (f, h) is laid on the crease (b, h) and then turned back, as shown in fig. 206, producing the crease (n, h). In like manner an intermediate crease is made in each of the other sections, so as to form a sort of fan, as represented in fig. 207. The points (a, b) are cut off with a sharp knife or scissors, and the filter opened to its proper angle by separating the originally doubled halves of the paper without disturbing the sharpness of the creases. It will now be found to consist of alternately projecting and receding angles, forming a uniform zigzag circumference, excepting at the points (c and d , fig. 207), at each of which places two projecting angles

come together. The intermediate portion of paper between these two angles should be folded so as to form a small receding angle, as shown at *e* and at *f*, fig. 208. This figure represents the appearance of the filter when completed.

Fig. 207.

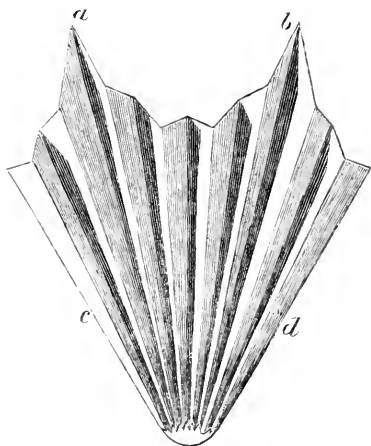
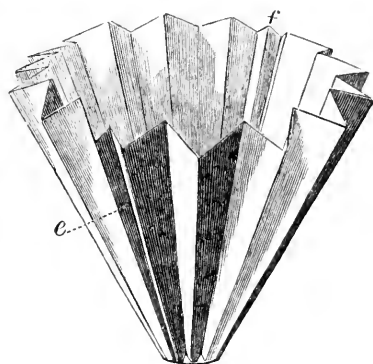


Fig. 208.



PLAIED FILTER.

When a filter breaks, the fracture generally occurs in the apex of the cone. This is the part on which the liquid exerts the greatest

Fig. 209.

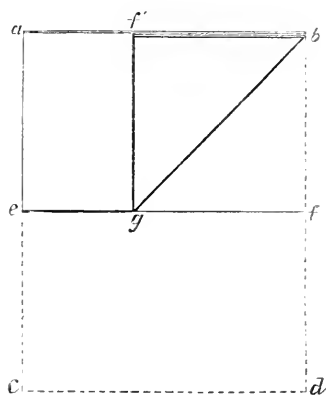
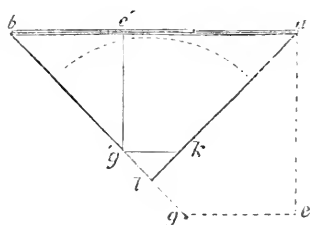


Fig. 210.



PLAIN FILTER WITH DOUBLED POINT.

pressure, and it also receives the smallest amount of support from the funnel. The plaited filter frequently breaks at this point, and to ob-

viate this result a little tow or carded cotton is sometimes put into the bottom of the funnel, so as to form a bed on which the point of the filter may rest.

There is a method of folding a plain filter by which increased strength is given to the point. The paper used in making it is not square, but oblong. It is folded so as to bring the two short ends ($a b$, and $c d$, fig. 209) together. The edge ($b f$) is then laid over $b f'$, producing the fold ($b g$). The paper, thus folded, is now turned over, as shown in fig. 210, and the edge ($a c$) laid over $a c'$, producing the fold ($a l$). Finally, the projecting points (a and b) are cut off in the direction of the dotted line. This filter will have a double thickness of paper at the apex ($g' k l$).

[A more simple arrangement is to cap the filter with a smaller plain one, the apex of which has been removed, so as not to obstruct the passage of the liquid, whilst it supports the filter; or a double filter may be used, the outer one having a number of holes cut in it.—W. P.]

In filtering volatile liquids, such as tinctures, and especially ethereal tinctures, much loss is frequently experienced from the evaporation which takes place during the process. To obviate this inconvenience, the arrangement represented in fig. 211, may be adopted. The funnel (a), the tube of which is inserted through a cork in the mouth of a bottle, has its upper edge ground to a smooth, plane, surface. Over this a circular piece of plate-glass is laid, and, if necessary, a little grease, such as the mixture of wax and lard, used for luting the joints of apparatus, may be rubbed on the edge of the funnel, so as to form an air-tight joint, which, on introducing a filter with a volatile liquid, will completely prevent evaporation. It will be necessary, however, to provide a channel through which the air from the bottle below may pass into the upper part of the funnel as the liquid descends, and this may be done by placing a piece of glass tube, about the eighth of an inch in diameter, between the filter and the funnel. The lower end of this tube should be twisted, in the way represented in fig. 212, to prevent it from slipping down through the neck of the funnel.

This arrangement will also be found convenient in filtering liquids, such as lime-water, and solution of caustic alkali, which it is desirable to exclude from the action of the air.

Fig. 211.



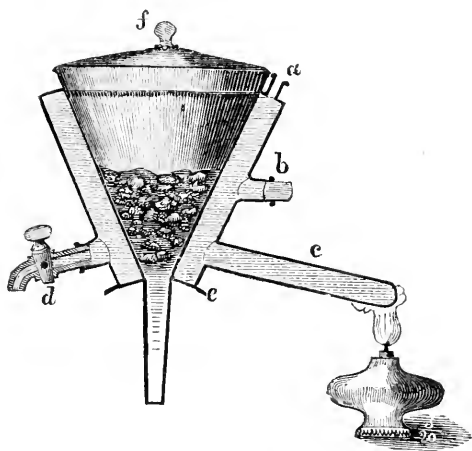
AIR-TIGHT FILTER.

Fig. 212.



There are some substances, the filtration of which can only be effected with the aid of heat. Solid fats, and thick oils and syrups, are of this class. In filtering such substances, the *Water-Bath Funnel* (fig. 213) will be found convenient. It is made of tin or copper, and consists of a funnel with an outside case or jacket, and an intermediate space for containing hot water. There is an opening (*a*) at the top for introducing the hot water into the jacket, and a projecting tube (*c*) near the bottom for keeping up the heat of the water by the flame of a lamp. It is convenient, but not necessary, to have a stop-cock (*d*) for drawing off the water from the jacket, and a short tube (*b*) through which steam may be introduced when it is more convenient to heat it by steam than by hot water. The projecting rim (*e*) is intended to prevent any water, running over at the tube *a*, from entering the bottle or other vessel in the mouth of which the neck of the funnel may be placed.

Fig. 213.



WATER-BATH FUNNEL.

Fig. 214.



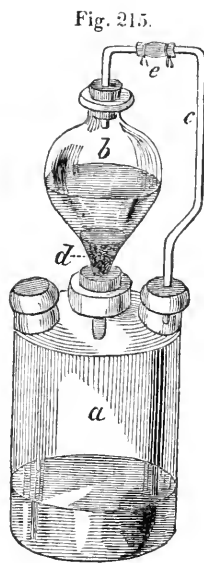
HOT FILTERING.

[Fig. 214 represents another instrument for filtering hot liquids, similar in its construction to that of Dr. Hare. It consists of a cylindrical tin case, penetrated vertically by an inverted cone or funnel, which is soldered tightly in its place. There is an opening at the top of the case for the admission of hot water, and for the escape of steam during the process of filtering, when the gas-burner is in action. The filter is placed in the conical cavity, the liquid to be fil-

tered introduced, and a cover placed over the top to prevent the cooling effect of evaporation. When the liquid to be filtered is an acid solution, or one capable of corroding the metallic surface of the instrument, a glass funnel with a small neck may be passed through a perforated cork, at the base of the funnel-shaped cavity, and the space between its exterior and the metal filled with water. The latter will receive and communicate heat just as in the first case.—W. P.]

Filters of inorganic materials are generally made by putting a bed of the inorganic substance at the bottom of a funnel through which the liquid is allowed to percolate. When sand or pounded glass is used, it is customary, in the first place, to put a few broken fragments of glass into the neck of the funnel, so as partly to stop it up, leaving such channels as may be further closed by other smaller fragments; then, to put a layer of coarsely pounded glass or sand, and over that some of the same material more finely divided. In this way, several strata may be laid so as to form a filter capable of separating solid particles from the liquor to the required extent. Pounded rock crystal is used in a similar way. Asbestos, when used, is merely put into the neck of a funnel, so as to form a loosely compressed plug through which the liquid can pass.

The apparatus originally suggested by Mr. Donovan, is frequently found convenient for effecting the filtration of liquids through inorganic materials. The immediate object, however, of this apparatus, is to prevent the absorption of carbonic acid from the atmosphere and also to prevent evaporation. The apparatus consists of a Wolf's bottle (*a*, fig. 215), into one of the necks of which an oil separator (*b*) is inserted through a perforated cork. The filtering medium (*d*), such as sand, pounded glass, or rock crystal, is packed in the separator in the manner already described, and the liquid to be filtered is poured over it. The mouth of the separator is closed with a cork, through which one end of the tube *c* passes, while the other end is inserted into the Wolf's bottle. The tube *c* is in two pieces, which are united by an India rubber connecter (*e*), so as to admit of the removal of the cork from the mouth of the vessel (*b*). As the liquid runs through the filter into *a*, the air passes from thence through the tube *c* into the upper part of *b*.



DONOVAN'S FILTER.

Animal Charcoal is used, for the purpose of filtration, in a somewhat similar manner to that adopted in the use of sand, glass, and rock crystal. The charcoal, in coarse grains, is made into a thick layer or bed, through which the liquid is filtered. The filters commonly employed in purifying water for domestic purposes, are made in this way. The water passes, first, through several successive strata of sand of different degrees of coarseness; then, through a thick bed of charcoal; and, lastly, through sand arranged as that through which it first passed.

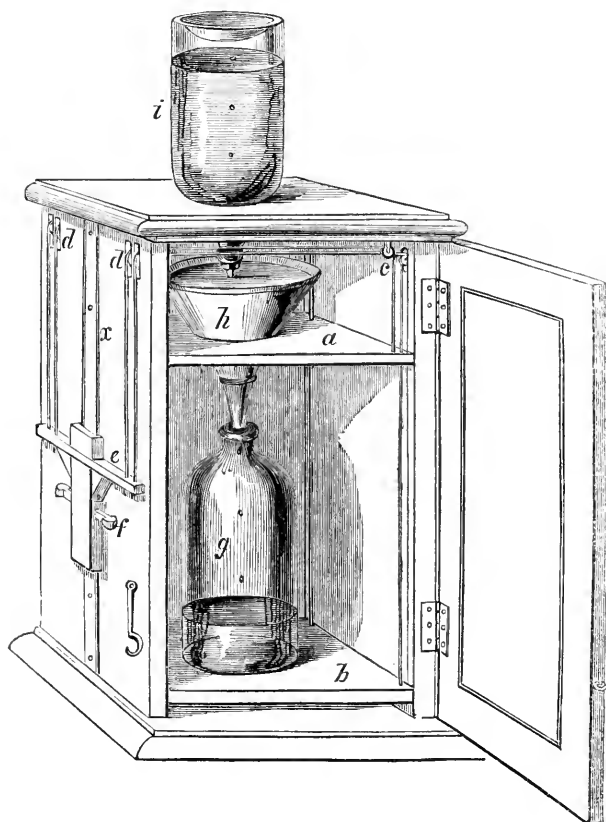
The principal use for animal charcoal is in the process of sugar-refining. The impure syrups are decolorized by passing them through beds of coarsely granulated charcoal packed in boxes or other suitable cases. As thus used, the charcoal itself forms the filtering medium, acting at the same time as a chemical and a mechanical filter. The property possessed by charcoal, and especially animal charcoal, of depriving liquids of their colour, and in some cases of removing offensive flavours, appears to depend upon its power of absorbing gases and other matters into its pores. Thus, a piece of box-wood charcoal which has been heated to redness, and while in this state, plunged into mercury, and allowed to cool out of contact with air, will absorb large quantities of gases when exposed to them. It will absorb thirty-five times its volume of carbonic acid, and ninety times its volume of ammoniacal gas. In like manner it absorbs the colouring matters of liquids, removing them from solution, and locking them up in its pores by a kind of surface attraction. Animal charcoal, made by the calcination of bones in close iron cylinders, possesses this property to a greater extent than wood charcoal; but in both cases there is a limit to the power of absorption. When the charcoal has ceased to act as a decolorizing or deodorizing agent, it may be restored to its original condition by calcining it in close vessels. The animal charcoal used by the sugar refiners is thus repeatedly restored.—(See DECOLORATION.)

In conducting the process of filtration, when a paper filter is used, and when the liquid to be filtered is an aqueous solution containing a precipitate, it is desirable, always, to wet the filter with distilled water, before pouring the solution into it. The effect of this is to cause the fibres of the paper to swell, and the pores to become smaller, so that the precipitate is less absorbed by the paper and is not so likely to pass through.

It is frequently desirable to have the means of keeping the filter constantly and uniformly supplied with the liquid to be filtered throughout the process. When this can be done it tends greatly to expedite

the filtration. A method of effecting it was recommended many years ago by Berzelius, which consists in inverting a narrow-mouthed bottle, containing the liquid under operation, over the filter, and fixing it in such a position that the mouth of the bottle shall be in contact with the liquid in the filter, when the latter is nearly full. While this is the case, none of the liquid will run out of the bottle, as the air cannot enter, but as the contents of the filter subside, the mouth of the bottle becomes exposed, and the liquid then runs out, its place being supplied by air which enters; and this will again cease as soon as the liquid in the filter rises so as to cover the mouth of the bottle.

Fig. 216.



ARRANGEMENT FOR CONTINUOUS FILTRATION.

The arrangement represented in fig. 216, is a convenient one for conducting the process of filtration continuously. It is that adopted by Mr. Abrahams, of Liverpool. There are two shelves, *a* and *b*, sus-

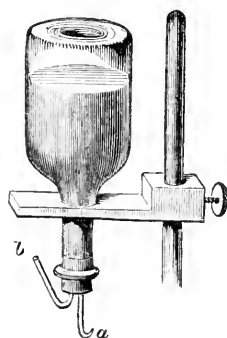
pended by cords in a square box or cupboard, the door of which opens as shown in the drawing. There is a circular hole in the centre of the shelf (*a*), and a corresponding one in the top of the box. The cords by which the shelves are suspended from their four corners, pass over small pulleys at *c, c, d, d*, through the two opposite sides of the box, and are fastened on the outside. Thus the four cords by which the shelf (*a*) is supported, pass through the left hand side of the box, and are fixed to the frame (*e*), the perpendicular bar of which is attached by a groove to the lath (*x*), along which it slides. This frame may be fixed at any point by means of the wedge (*f*). By loosening the wedge, therefore, and moving the frame (*e*), upwards or downwards, the position of the shelf (*a*) is easily altered, and on again tightening the wedge it is fixed in its new position. The cords by which the shelf (*b*) is suspended pass out on the opposite side of the box, and are fastened there in a similar way.

Two bottles of equal size are used in conducting the process of filtration. The bottle (*i*) is filled with the liquid to be filtered, and to the mouth of it is fitted a cork through which passes a short piece of tube, about a quarter of an inch in diameter. The bottle (*g*) being empty, is placed on the shelf (*b*) to receive the filtered liquor; the filter (*h*) is supported on the shelf (*a*); and the bottle (*i*) is placed on the top of the box, with its mouth inverted, and the end of the tube in contact with the liquid in the filter. The height of the shelves is adjusted by the cords so as to bring the several parts to their proper positions. The apparatus being thus arranged, the filtration will go on until the bottle (*i*) is emptied, without any interruption occurring from the want of a uniform supply of liquid to the filter.

Instead of having merely a straight piece of tube inserted in the

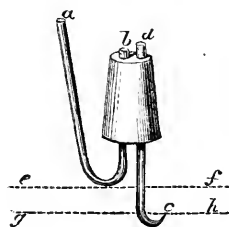
mouth of the bottle from which the liquid is supplied, as in fig. 216, two tubes are sometimes used, as shown in fig. 217. In this case the efflux tube (*a*) is turned up at the end, and as the liquid runs out here air enters at *b*. The surface of the liquid into which (*a*) is immersed must, however, be so far below the lowest point of *b* as to enable the air to depress the liquid in the external ascending part of *b*, and thus to enter the bottle. This is shown in fig. 218 by the distance between the lines (*c f* and *g h*). The size of the tubes is also so arranged that the liquid will not run

Fig. 217.



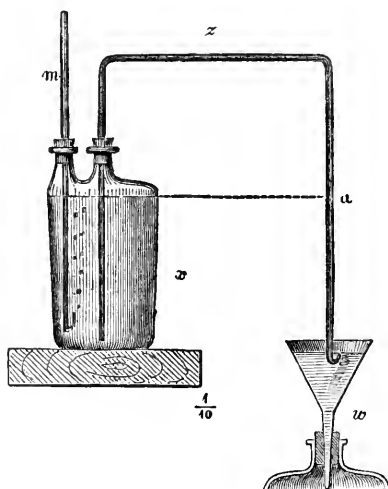
from *a*, fig. 217, unless the orifice of the tube be in contact with the contents of the filter, so that the cohesive attraction of the liquid may overcome the capillary attraction. Fig. 218, will further illustrate the arrangement of the tubes. The opening (*a*) of the tube (*a, b*) must be higher than *b*, otherwise the fluid would spurt out at *a* as each bubble of air passed. The point (*d*) should also be higher than *b*, otherwise when the level of the liquid in the bottle became lower than *b* it would run continuously through *d*, and might cause the filter to overflow.

Fig. 218.



Gay-Lussac's arrangement for continuous filtration is a good one, and in some cases is preferable to all others in use. This arrangement is represented in fig. 219. The liquid to be filtered is put into a two-necked bottle (*x*), or into a wide-mouthed bottle with a cork through which two tubes can pass. The tube (*z*) is bent twice at right angles, and one of its limbs is inserted into the bottle (*x*), so as to reach nearly to the bottom; the other limb terminates in the funnel (*w*), which is so placed that the surface of the liquid in the filter, when filled, shall be on a level with the end of the tube (*z*), in the bottle (*x*). The second tube (*m*) is also inserted into the bottle (*x*) to the same depth as *z*. On commencing the process,

Fig. 219.



air is blown through the tube (*m*) into the bottle (*x*) until the liquid rises in the tube (*z*), and flows into the filter. The current, being thus established, will continue until the liquid in the filter rises to a level with the ends of the tubes (*z* and *m*) in the bottle (*x*); it will then cease, but as the liquid in the filter subsides, a fresh portion will run through the tube (*z*), so as to maintain a uniform supply, and bubbles of air will at the same time enter (*x*) through the tube (*m*). It will be obvious that in this case the tube (*z*) acts as a syphon, the force determining the current being equivalent to the weight of the column of water (*a w*), and when this column exceeds that of the immersed

part of the tube (*m*) air will enter *x*, and the liquid at the same time flow into *w*.

When the filter contains a precipitate which is required to be washed, it should first be collected into the apex of the funnel by directing a jet of water from a syringe or wash-bottle against it, and the further washing may be effected either by the same means, or by one of the continuous processes already described.

[When a recent precipitate is poured into a filter and the excess of fluid suffered to drain, a conical cavity is formed in the centre. There is a decided advantage in allowing this to remain, and keeping the cavity constantly filled with the washing fluid, which is then compelled to pass through, and lixiviate the soluble matter; whilst if its surface

Fig. 220.

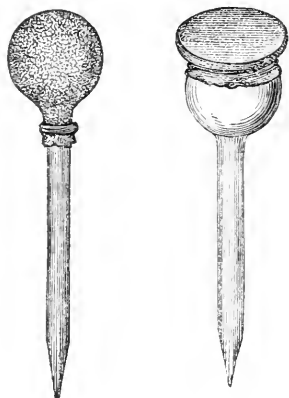


Fig. 221.



is level, the great body of the liquid will pass through the paper above the surface of the precipitate, and along the sides of the funnel. Owing to the pasty nature of some precipitates, it is difficult to wash them completely at one operation; and they have either to be stirred up in the filter with the feather end of a quill, or the whole removed to a capsule, the first filter washed off and a new one substituted, the precipitate being poured on the new filter after admixture with more water. Gelatinous precipitates are best washed by decantation. The plain filter should always be used for washing precipitates, as it is less liable to tear in the removal of the precipitate; and in removing the filter from the funnel it should be laid on the single side, which admits of the folded part being opened without disturbing the precipitate, which then remains in one mass. It is, generally speaking, better

that the filter does not extend beyond the funnel, so that by covering the latter, evaporation from the edges of the paper will be prevented. In cases where great delicacy is required, when a weighed filter is used in analysis, for instance, the pipette, fig. 220, or the washing bottle, fig. 221, should be employed both to remove all traces of the substance to be washed from the containing vessel to the filter, as well as to wash the edges of the filter.

When a liquid is poured into a filter, the latter should be held in contact with the funnel, in its proper position, and the stream of the added fluid be made to impinge against the side, and not on the point of the filter where it is unsupported. Beginners are very apt to rupture filters by not observing this precaution. A plain filter should never be placed in a funnel, the sides of which curve outward in a bell shape, but in the fluted filter this is of no account.—W. P.]

The most simple form of wash-bottle is made by inserting a glass tube, with a capillary orifice, through the cork of a bottle, such as figs. 222 and 223. In using this bottle, it is partly filled with water, and air is then blown in through the tube so as to compress that contained within; the bottle is then immediately inverted over the filter, and a jet of water is forced out by the elasticity of the compressed air.

Fig. 224 is a more convenient form of wash-bottle, in which two tubes are used, one terminating near the top, above the liquid, and the other beneath the liquid and near the bottom. Air is blown in through the former, which forces the liquid out through the latter. In this case the bottle is not inverted during the use of it, and the jet of water can be maintained without interruption, which are advantages.

Fig. 222.



Fig. 223.



Fig. 224.



WASH-BOTTLES

In one respect, however, this form of wash-bottle is less convenient than the other. As the water continues to flow only so long as the

blowing is continued, it is necessary in directing the jet to different parts of the filter, that the head of the operator as well as the bottle should be moved. This defect might be obviated by attaching a valve to the end of the tube through which the air is compressed. The extremity of the tube being ground perfectly flat and smooth, a piece of Indian-rubber is fixed over it by two pins, as shown in fig. 225. On blowing strongly through the tube the valve will recede, and the

Fig. 225.

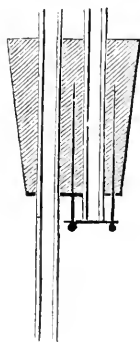
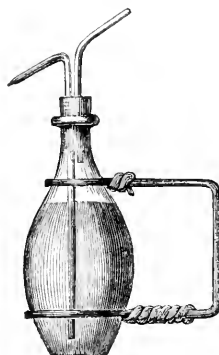


Fig. 226.



WASH-BOTTLE.

air become compressed within the bottle; but on ceasing to blow, the elasticity of the air pressing the Indian-rubber against the orifice over which it is placed, no escape can take place here, while a continued jet of water will be forced through the exit-tube.

If it should be required to wash a precipitate with hot water, the best form of wash-bottle to use is

that represented in fig. 226. This differs only from fig. 224, in being provided with a handle.

CLARIFICATION.

The term *clarification* is applied to processes by which mechanical separation of substances that impair the transparency of liquids is effected by means which are accessory to filtration or decantation.

In most cases in which clarification is performed for pharmaceutical purposes, it is effected through the agency of heat, but the process is varied according to the nature of the substance operated upon.

In some instances the separation of substances which occasion opacity is only prevented by the viscid character of the liquid in which they are suspended; and the mere application of heat, by increasing the fluidity of the liquid, enables the particles to separate spontaneously by virtue of their greater or less specific gravity. This is the case with honey, which is clarified by keeping it melted by the heat of a water-bath, when some of its impurities, being heavier than the honey, will subside, while others, such as wax, being lighter, will rise to the

surface, and may then be removed by a skimmer. It is essential in doing this that the substance under operation should be left undisturbed by agitation while the separation is taking place.

If there should be any particles in a viscid liquid which will not separate spontaneously on the mere application of a gentle heat, in consequence of their specific gravity being the same, or nearly the same, as that of the liquid in which they are suspended, ebullition may facilitate the separation. Thus, if a liquid of this kind be boiled, the steam being generated most freely in contact with the solid particles, and small bubbles of steam remaining attached to such particles, they will be carried to the surface by the buoyancy of the steam.

It very frequently happens in pharmaceutical processes, that the clarification of a liquid takes place on heating it, in consequence of its containing a substance, originally in solution, which is rendered insoluble by the heat. This is the case with most vegetable juices which contain albumen, and this, on assuming the solid condition, envelopes any particles which may be suspended in the liquid, and either carries them to the surface, or subsides with them to the bottom. It is, indeed, through the intervention of albumen that clarification is generally effected for pharmaceutical purposes; and if this substance be not one of the constituents of the liquid to be clarified, it is frequently added, to insure the desired result. In using albumen for this purpose, it must be added to the liquid before the application of heat. White of egg is the kind of albumen generally employed, and this should be first mixed with a little water, then the mixture intimately diffused through the liquid, which should be gradually heated until coagulation takes place, without disturbing it by stirring or other agitation.

It is necessary to be cautious in the use of albumen as a clarifying agent in pharmaceutical processes, as it sometimes combines with, and thus causes the separation of some of the active constituents of the liquid to which it is added.

[Clarification is sometimes effected by means of fermentation, in certain glutinous juices, as that of buckthorn-berries. The fixed oils are clarified by long standing: the flocculent albuminous matter gradually separates, and forms a precipitate at the bottom. Warm weather is best for this operation, and the oil should be carefully protected from the action of the air during the deposition of the impurities.

Gelatin is a good clarifying agent when the liquid contains tannin; and when acid is predominant, as in certain wines, cider, etc., milk

may be used with advantage. In this instance, it is the caseine which is coagulated by the acid, the coagulum seizing on the impurities as in the case of albumen.

The pulp of paper when disseminated through a troubled liquid, will often effect its clarification by subsidence.—W. P.]

DECOLORATION.

[Decoloration, in a pharmaceutical sense, means the process by which liquids, or solids in solution, are deprived wholly or partially of their colour, by bringing them in contact with animal charcoal; although in the arts the meaning is extended to include bleaching in general, by chlorine, chromic acid, etc.

M. Lowitz, of St. Petersburg, first noticed the decolorizing property of vegetable charcoal, but the superior power of that of animal origin was discovered by M. Figuier, of Montpellier, in France.

This remarkable property of carbon appears to be in proportion to its porosity; hence in carbonizing animal matter for the purposes of decoloration, it is best to mix it with some inorganic substance that will insinuate itself into the pores of the matter, and keep it from fusing, and which can be dissolved out afterwards. The phosphate of lime in bones acts in this manner. When, however, blood is mixed with a tenth of its weight of carbonate of potassa, evaporated to dryness, the dry mass carbonized at a red heat in a crucible, in which it is suffered to cool out of contact with the air, and afterwards deprived of alkali by repeated ebullition with water, the charcoal which remains possesses the decolorizing power in a higher degree than that prepared in any other way; it having twenty times the efficiency of good bone-black.

When bone-black is treated with its weight of muriatic acid, diluted with as much water, by the process of the U. S. Pharmacopœia, the phosphate of lime and the sulphurets of lime and iron are removed, and the residual carbon is much improved in its decolorizing value.

MM. Bussy, Payen, and Defosses, have shown that the union takes place between the carbon and colouring matter. Until recently, the action of the charcoal was supposed to be confined to colouring and odorous substances, but MM. Weppen and Garrod have proved that bitter proximate principles, alkaloids, resins, and even mineral substances, as arsenious acid and corrosive sublimate, may be removed from their solutions by it; and they have recommended its use as an antidote.

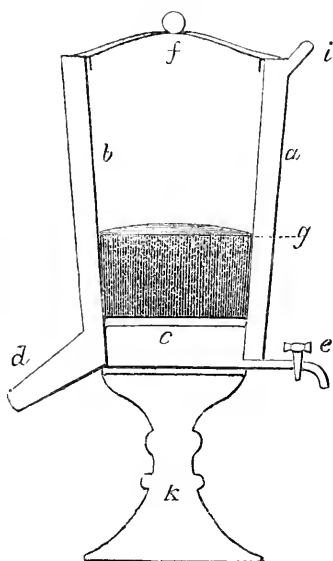
Yet more recently M. Lebourdais has proposed animal charcoal as an agent in organic analysis, for removing the peculiar principles of plants from their decoctions and infusions, with the design of subsequently extracting them from the charcoal by alcohol. Digitalin, arnicin, and others have been isolated in this manner. (*Am. Jour. Pharm.*, vol. xxi. p. 87.)

Animal charcoal is employed in pharmacy for decolorizing syrups, honey, saline solutions previous to crystallization, the organic acids, alkalis, and neutral principles, resins, fixed oils, and in deodorizing alcohol and other liquids.

The mode of using charcoal varies with the object. Sometimes it is merely shaken with the liquid without heat; more generally they are heated or boiled together and subsequently separated by filtration. When large quantities of syrup or oils are to be treated, they are filtered through a stratum of granulated charcoal, as in Dumont's filter. This instrument is a box, in shape the frustrum of a square pyramid, inverted, and has a diaphragm near its bottom, on which rests a stratum of granular animal charcoal of the size of gunpowder. A layer of coarse clean sand is placed over this, and on the sand a blanket cloth to prevent the disturbance of the layers by pouring in the fluid.

A convenient arrangement for the pharmacist whose operations are limited, is that at fig. 227, which may be used for syrups, honey, fixed oils, or any permanent solution of organic matter not capable of corroding the vessel. This instrument consists of a cylindrical or slightly conical vessel *a*, ten inches in diameter, enclosing another, *b*, eight inches in diameter, in such a manner that the space between them will hold water, which may be kept hot by applying the flame of a lamp to the tubular projection *d*; *e* is a diaphragm of perforated tin; *e*, a stop-cock, communicating with the inner vessel; *i*, an orifice for introducing the hot water; *g* the surface of the carbon. When used for fixed oil, syrup, or other thick liquid, the outer vessel is kept full of hot water, to facilitate the passage of the fluid. All liquids to be de-

Fig. 227.



CHARCOAL FILTER FOR DECOLORIZING.

colorized in this way should be free from flocculent particles, as these interfere with the passage of the fluid through the charcoal, and the latter, except in the case of fixed oils, should be moistened with water.

Resins, as that of jalap, are decolorized by mixing their powders with an equal bulk of charcoal, introducing the mixture into a displacer of suitable size on top of a layer of charcoal, and then passing alcohol, sp. gr. $\cdot 835$, through the filter till the resin is dissolved out. The solution thus obtained is colourless, and by evaporation at a low temperature yields the resin in a colourless form. There is always a loss, however, due to the combining power of the carbon. For the treatment of syrups, see the chapter on Solutions.—W. P.]

CHAPTER VIII.

THE PRESS. THE PROCESS OF EXPRESSION.

THE press is used in pharmaceutical laboratories for effecting the separation of liquids from solids where much force is required. In the use of this instrument the power of the human arm is increased by mechanical means, at the expense of time and space. The screw and the lever are generally applied for this purpose.

Bramah's hydraulic press is rarely used in the laboratory, the circumstances under which it would have to be employed being such as to cause frequent derangements, requiring the assistance of a class of mechanists who are not to be met with in every locality.

The screw-press, being less complicated than Bramah's, is not so liable to accidents. Consisting only of solid parts, it is less affected by being left unused for some time. Its construction is simple and easily comprehended by any person, and the repairs which it may require can be executed by the common mechanists in wood and iron.

There are two kinds of screw-press,—one having a single screw, and the other two screws. The screw in the former is vertical, effecting a downward pressure on the bag, which is placed horizontally. In the latter the screw acts horizontally, while the bag is placed in a vertical position.

Opinions are divided as to the relative advantages of these two kinds of press. There is no doubt that the single-screw-press, as commonly constructed, is inferior to the double-screw-press; but I think I shall be able to show that the former may, by an improved construction, be rendered quite as useful and compact as the latter.

The following are the objections which principally apply to the single-screw-press as usually constructed:—

1. The press-block attached to the screw frequently loses its horizontal position, being turned to one side in consequence of some defect in filling or placing the bag, so that it becomes necessary in the middle of an operation to unscrew the press and rearrange the bag. If this be neglected, the press-block will come in contact with the sides of

the box, thus causing violent friction and partial resistance ; the screw itself is also liable to be injured from its being forced out of the perpendicular.

2. The expressed liquid does not run off freely from a press-box placed horizontally. If the press be so arranged that it may be tilted, it would be necessary that the means by which it is fixed to the wall should be movable ; and, as the press cannot be used while in the tilted position, much trouble would be involved in thus repeatedly moving the press every time it is used.

3. The use of this kind of press is not free from some danger. The entire force of the lever is directed horizontally, and is sustained by the fastening of the press to the wall. If the application of much force should cause the fastening to give way, or the lever to break, the operator may suffer serious injury ; and damage in other respects would necessarily be incurred. Accidents from this cause are not unfrequent.

4. With this press the male screw alone moves, while the female screw or nut remains stationary. Under these circumstances the screw suffers a severe torsion, as the tangential impulse received at one end is communicated to the other through the whole length of the screw ; and it is much more likely in this way to suffer injury, than would be the case if the male screw were fixed, and the female screw or nut movable.

Let us now consider what advantages are possessed by the double-screw-press, as compared with that last noticed.

1. The press-bag is very easily placed in its right position, as the two screws are visible between the side plates, and afford a measure by which to adjust the bag. Should there, however, be any inequality in the tightening of the screws, this may be easily rectified, by applying more force at that end of the press-plate which had least progressed. To admit of this inequality in the progression of the two ends of the press-plate, it is desirable that the nuts should be rather loose.

2. The expressed fluids run down the vertical sides of the press-plates and from the sides of the bag without any impediment ; no provision for tilting the press is required ; and the fastenings by which the press is fixed to the wall need not be so strong as in the case of the single-screw-press. With careful management, the press need not even be fixed to the wall at all.

3. This kind of press occupies less room than the other, and, when not in use, it may be converted into a temporary table, or removed altogether out of the way.

4. The use of this press is unattended by the same danger of injury to the operator, as in the case of the single-screw-press.

5. The power of the screw is applied in the most advantageous manner, the male screw being fixed, while the female screw or nut is moved.

6. The press-plates may be easily covered with different materials, best suited for the purposes to which the press is applied. Thus cast iron may be used for fixed oils, pine wood for the coloured juices of fruit, and tin for tinctures and other alcoholic or aqueous solutions. It is much easier to cover the press-plates with these materials, than it would be to line the press-box and block used with the vertical press in a similar manner.

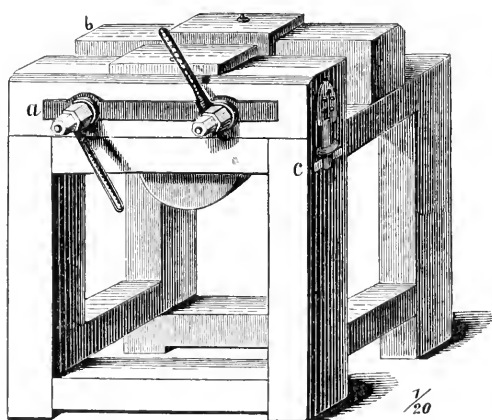
Having thus noticed the principle of the screw-press, and the relative advantages and disadvantages of the two kinds which are used, it remains to treat of the construction and application of these presses.

Fig. 228 represents a double-screw-press in perspective, drawn to one-twentieth the real size. The drawing has been made from a press, which, after many alterations, has assumed the form and dimensions indicated. This press has been used for the last ten years, without requiring any repairs.

The dimensions appear to be such as best to adapt it for the requirements of a laboratory, where either large or small quantities of materials are operated upon, and any deviations from these dimensions would probably entail inconveniences which may not be foreseen.

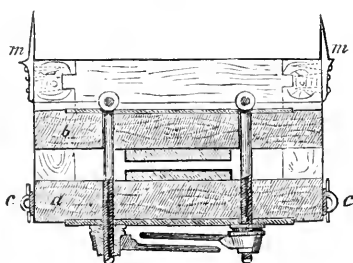
Fig. 229, represents a transverse horizontal section of the press, through the screws, as seen from above.

Fig. 228.



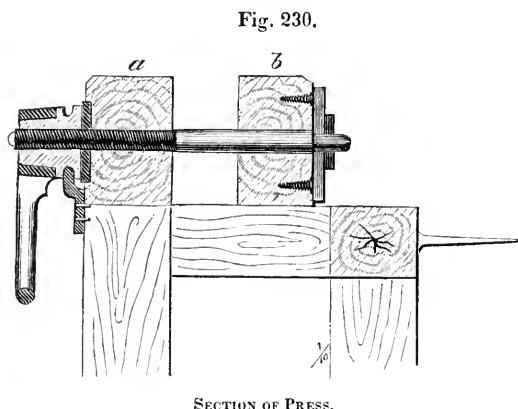
DOUBLE-SCREW, OR HORIZONTAL PRESS.

Fig. 229.



SECTION OF PRESS.

Fig. 230 is a vertical section through one of the screws, as seen from one side.



The press consists essentially of two parts,—the stand or support, and the press which rests on the top of it. The stand is an oblong framework of wood, the height of which is such as to admit of the application of the full force of the arm to the screws. This framework is made of oak, or other

durable wood, and it should be well put together, with a view to the attainment of strength.

The stand may be fixed to the wall against which it is intended to be placed by two fastenings, one at each end, as shown at *m m*, fig. 229. In some cases, however, it may be found convenient to be able to move the press; and, to admit of this, a different kind of fastening from that represented in the drawing must be used.

The press itself consists, in the first place, of two blocks of good beech-wood, free from knots, as shown in figs. 228, 229, 230, at *a*, *b*. These blocks of wood are thirty-two inches in length, eight inches and a half in height, and four inches in width, or thickness. The front block is fixed at each end to the framework, in such a manner that by merely knocking out a bolt, as shown at *c*, figs. 228 and 229, it may be removed at any time, and again fixed in its place with the greatest facility. The other block (*b*) is movable, being made to slide on the top of the framework of the stand.

But the most essential and important parts of the press are the screws, by which the pressure is effected. These should combine as much strength, and as little friction, as are compatible with the full attainment of the required object. If the size of the screws be unnecessarily augmented, the friction will be increased, yet they must be sufficiently large to insure the required strength. English cast steel, which has been submitted to a low red heat in a charcoal fire, is the best material of which to make the screws. The entire length of the screws is seventeen inches, but the thread of the screw extends over about one-half only of this length.

There are two forms which are given to the thread or worm of a screw: the first presents a sharp edge externally, and forms, in section, a triangle, attached by one of its sides to the cylinder of the screw; the second presents a flattened surface externally, and forms, in section, a square, attached to the cylinder by one of its faces. Of these two forms, the first imparts the greater strength, for supposing the inclination of the plane to be equal in both, the triangular thread will be attached to the cylinder by a base which will be twice the size of that of the square thread.

The tendency of the application of the motive power to the screw is either to tear the thread from the cylinder, or to advance the outer edge along the inclined plane. The thread itself, therefore, is a lever, the extreme fulcrum of which is on its outer edge; and, as the strength of the lever ought to increase with increase of length, the greatest strength is required at the end next the cylinder, where the power is applied.

In like manner, this form gives the greatest strength to the female screw or nut, which consists of a triangular thread attached to the inner surface of a hollow cylinder.

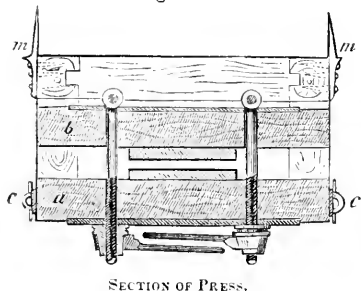
The space between the edges of two neighbouring threads is called the groove, and the depth of the thread is calculated from the outer edge to the cylinder. A good screw ought to be so cut that the depth of the groove shall be greater than the base of the thread. A transverse section of the thread, therefore, would represent, not an equilateral, but an isosceles triangle, the most acute angle of which forms the outer edge. In determining the proper depth and width for the groove of a screw, a due proportion must be observed between the thickness of the entire body of the screw and the dimensions of the thread. If the groove be cut too deep in proportion to the size of the cylinder, the latter will be incapable of offering a power of resistance equal to that of the thread; and, on the other hand, if it be made too shallow, the cylinder would bear a force greater than the thread could sustain. Supposing the original size of the cylinder from which the screw is to be cut to be one inch in diameter, the groove should be one line and a half in width, and two lines in depth, thus leaving eight lines or two-thirds of an inch as the diameter of the remaining cylinder.

Each of the press-plates, or blocks of wood, (*a*, *b*, figs. 228, 229, 230,) is strengthened by a strong plate of iron, fixed as shown at *a*, fig. 228. The screws of the press pass through these plates, as well as through the blocks, and the holes made for the screws should be rather oblong, so as to admit, to a slight extent, of the unequal pro-

gression of the two ends of the block. Between the iron plate and the nut of the screw there should be a ring of polished steel, forming a sort of washer.

The nuts are turned by levers, having hexagonal holes, or sockets, into which the nuts exactly fit. The hexagonal form is the best for the sockets of the levers, for if, as is sometimes the case, they have a quadrangular form, there will be too little choice of position in fitting the lever on, so as to exert the force with greatest effect; while, on the other hand, if they have the octagonal form, the angles will be so obtuse, that after some wear the lever will lose its purchase, and turn without effect.

Fig. 231.



circle without touching the screw of the other.

The proper forcing lever (fig. 232) should be from thirty to forty inches in length, and should have a strong hexagonal socket. It must be bent, as shown in the drawing, so as to admit (when fixed on one screw) of its passing the end of the other even when the press is quite closed. The lever should be made of a bar of iron having greater width than thickness; and the narrow side should be presented in the direction of its movement, so as to give the greatest possible strength compatible with its bulk and weight. Round bars are more easily bent, and ought not to be used.

Fig. 232.



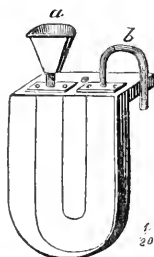
LEVER OF PRESS.

Only one long lever is used, this being applied alternately to the two screws; but care must be taken that the press-plates be kept as nearly parallel as possible.

The shape and size of the blocks of wood forming the press-plates have been already noticed. These are lined, on the sides which come in contact with the substances to be pressed, with tin plates, which, however, may be removed, and some other material

substituted, better suited for the expression of any particular substance that may be operated upon. Thus, for substances containing mineral or other acids, such as the juices of fruits, &c., deal boards previously well soaked in water may be used; and, for fixed oils, iron plates will be found to answer best. When iron plates are used, it will sometimes be found convenient to have them hollow, as represented in fig. 233. A partition, not reaching quite to the bottom, divides the hollow part of this plate in the middle. This partition has the double object of strengthening the plate, and of causing a current of hot water, when poured in through the funnel (*a*), to pass to the bottom of the plate, and flow out through the syphon (*b*), the top of the funnel being higher than the highest point of the syphon.

Fig. 233.



IRON PRESS-PLATE.

With this arrangement, the press-plates are easily kept warm, for the expression of any particular substances, by supplying them with boiling water. In the expression of butter of cacao, oil of eggs, almond oil, and indeed most solid and liquid fats, also plasters, resins, and gum-resins, it will be found advantageous to employ more or less heat in the process. These plates may be eleven inches and a half wide, from thirteen to fifteen inches deep, and about one inch and a half thick. The hollow space may occupy about half an inch of the thickness, leaving half an inch for the thickness of the iron.

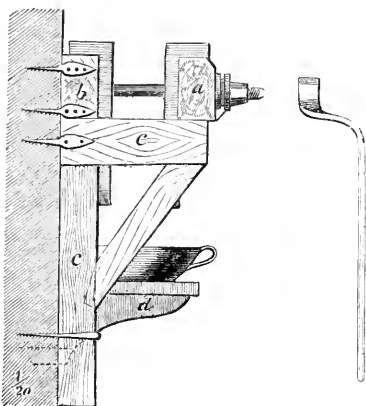
This kind of press is in very general use, although not always constructed precisely according to the instructions here given. Having a complete framework and stand of its own, which adapts it for use, even without being fixed to a wall, it may be moved from place to place in the laboratory.

In those cases, however, where the means of moving the press is not a consideration, it may be found more convenient to attach it to a different kind of framework, which would occupy less space.

Fig. 234 represents a press, having all the essential parts of that

Fig. 234.

Fig. 235.



DOUBLE-SCREW, OR HORIZONTAL PRESS.

last described, but with certain modifications in the method of fixing it. Thus, the press-block (*b*), as well as the framework or support (*c, c*), are securely fastened against a wall, in the manner represented in the drawing; and a shelf (*d*) is also fixed below the press, for the reception of a vessel to receive the expressed liquor. The form of the bent lever is further illustrated by fig. 235.

It is sometimes urged as an objection against these double-screw or horizontal presses, that, as there are two screws to be turned, which can only be worked alternately, more time is occupied in the process than is the case with the single-screw-press; and, unless great care be taken, the screws may be injured by causing one end of the press-plate to progress too much in advance of the other.

These objections are certainly well founded, but they may be entirely obviated by making a very simple addition to the apparatus in the following manner:—Three cog-wheels are to be selected, of such diameter that two of them being fixed on the nuts of the two press-screws, the third shall exactly occupy the space between them. These cog-wheels must all work in gear; the two which are attached to the screws must be precisely similar, but the third or centre one may be of a different size, provided the cogs or teeth correspond. This last must work on a strong pivot fixed to the plate of iron, which, as already stated, is attached to the front of the press-block to increase its strength. By this means, on turning the centre wheel, the two screws will be worked simultaneously; but while an advantage is thus gained, in some respects, there is, on the other hand, a disadvantage in the loss of power, to compensate for which a longer lever must be employed.

There are, however, many advocates for the *single-screw* or *vertical press*; and as this certainly has some advantages, I will now describe the best method of constructing it.

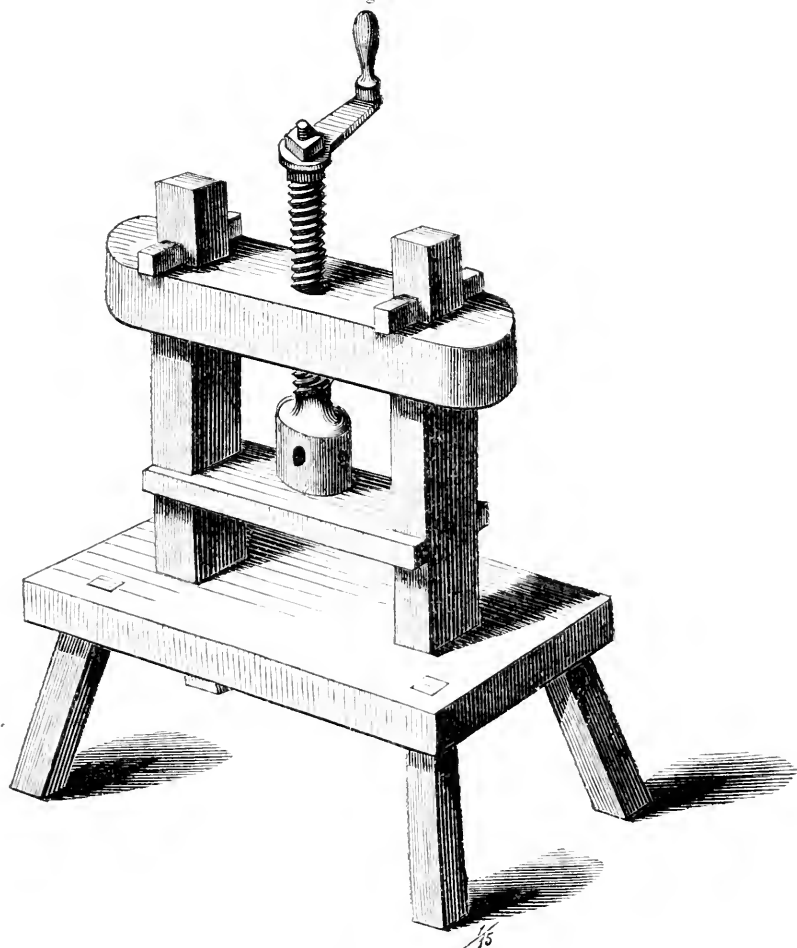
The greatest fault in the single-screw-press, as commonly met with, is, that the screw is sometimes turned from the perpendicular, and forced into a more or less oblique direction, in consequence of inequalities in the resistance offered by the substance pressed. This may be obviated by adopting a suitable method of guiding and confining the direction of the screw.

As these presses may be made entirely of wood, at little expense, I will first describe the most approved kind of wooden press.

Fig. 236 represents one of these presses, drawn to one-fifteenth its real size. It consists of a low table or stand, in the thick top of which the framework of the press is fixed. The screw should be

made of the best dry beech-wood, and should terminate at the bottom in a stout cylindrical knob, through which two holes are bored at

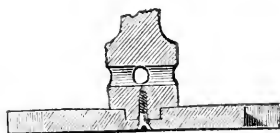
Fig. 236.



WOODEN SINGLE-SCREW, OR VERTICAL PRESS.

right angles to each other for the reception of the lever. A vertical section of this enlarged termination of the screw, together with the press-plate, is represented in fig. 237, where it will be seen that the former works in a hole in the centre of the latter, which prevents it from slipping to either side. Some hard soap should be put into this hole, to counteract the friction that would otherwise occur.

Fig. 237.

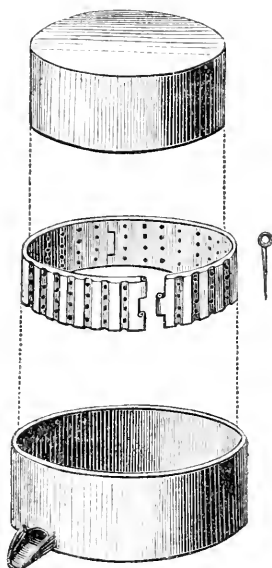


The press-plate is guided by two arms, which embrace the uprights of the framework, and keep it in the horizontal position. At the top of the screw there is a handle, which serves for screwing or unscrewing the press expeditiously when the long lever is not required.

Fig. 238.

Fig. 239.

Fig. 240.



It will be evident that the press-bag could not be placed immediately on this press, as here represented, as there is no provision for collecting the expressed liquid, or guiding it into any vessel. A particular apparatus will be required for this purpose. This consists, first, of a low cylindrical vessel (fig. 240) made of copper well tinned. If the bag be so small as not to come in con-

tact with the sides of this vessel while being pressed, it may be introduced without further provision. The wooden block, (fig. 238,) which is covered with tin plate, is placed on the bag, and they are then put under the screw to receive the required pressure.

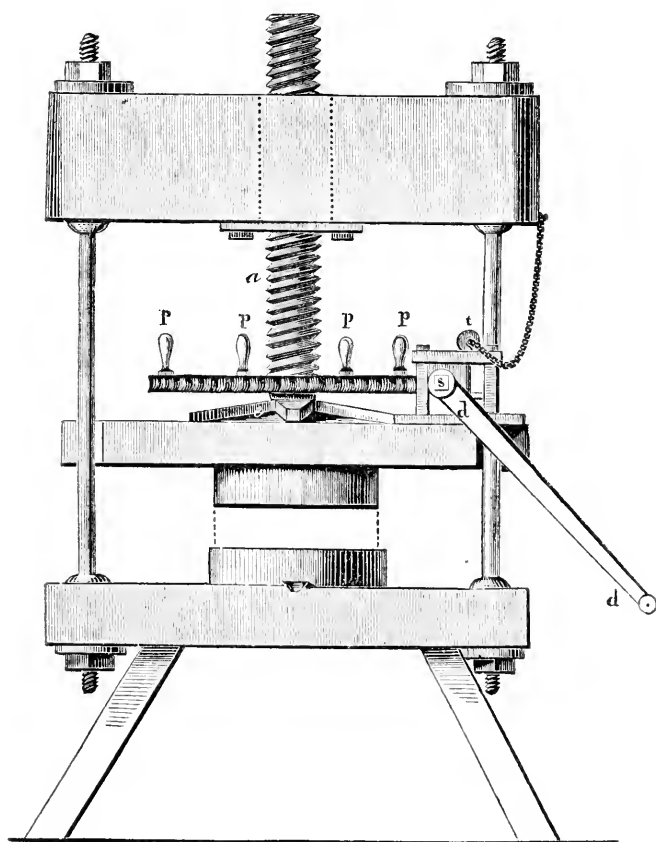
Should the bag be likely to come in contact with the sides of the press-box, it will be desirable to use a perforated internal case (fig. 239). This is made in two parts, being united on one side by a hinge, and temporarily joined on the opposite side by a pin, as shown in the drawing. The inner surface of this cylindrical case is smooth, but the outer surface is grooved, the holes through which the expressed liquid is intended to pass being made into these grooves.

The power of the screw-press may be greatly increased by substituting for the simple lever a cog-wheel, attached to the screw of the press, and worked by an endless screw, as shown in fig. 241. In this drawing, *a* represents the press-screw, to the lower end of which the cog-wheel is securely fixed; and the endless screw (*s*), which is turned by the lever (*d d*), bites into the teeth of the latter.

Under this arrangement power is gained in two ways. The lever or handle (*d d*) produces an increase of power in proportion as its arm is longer than the radius of the endless screw (*s*); and this screw increases the power in proportion as its circumference is greater than

the width of its grooves. These two increments, multiplied the one into the other, will give the first product. Then, in the next place,

Fig. 241.



SINGLE-SCREW, OR VERTICAL PRESS.

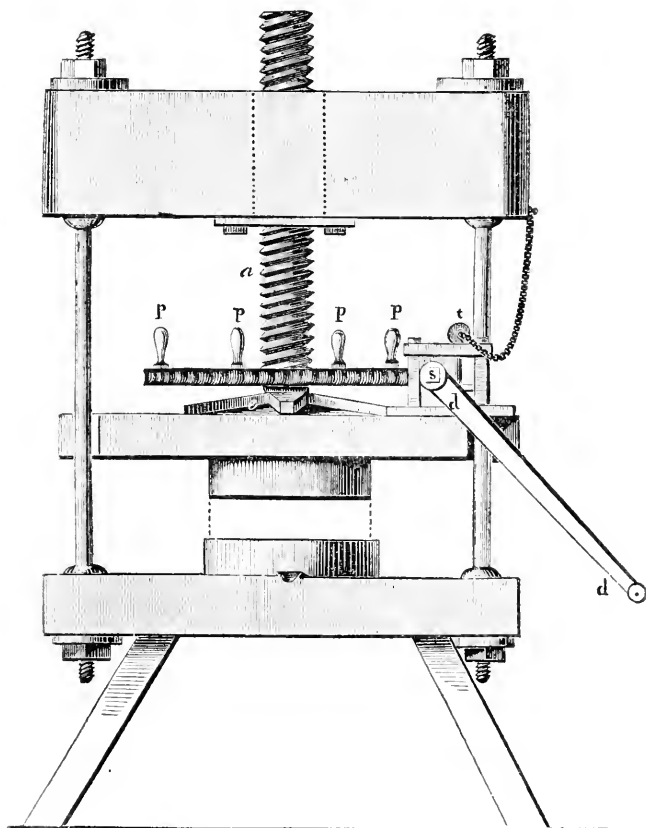
the cog-wheel which is fixed to the screw acts as a lever, producing an increase of power in proportion as its diameter is greater than that of the screw; and the latter again increases the power in proportion as its circumference exceeds the width of its grooves. These latter increments, multiplied together, give the second product, and the two products multiplied together give the sum total of the increase of power over that exerted at the lever.

Thus, assuming, for the sake of illustration, that the arm of the lever (d) is twelve times the length of the radius of the endless screw (s), and that the grooves in the latter are one-tenth its circumference,

the increase of power in these parts will be $10 \times 12 = 120$. Then, assuming the diameter of the cog-wheel to be eight times that of the screw a , and the width of the grooves in the latter to be one-tenth its circumference, the increase of power here will be $8 \times 10 = 80$. And now, if these two products be multiplied together, we shall have $120 \times 80 = 9600$ as the sum total of the rate of increase of power.

If we further assume, that a man in working the press applies a force equal to 100lb. to the lever, the theoretical amount of pressure exerted by the screw would be $9600 \times 100 = 960,000$ lb.; but from

Fig. 242.



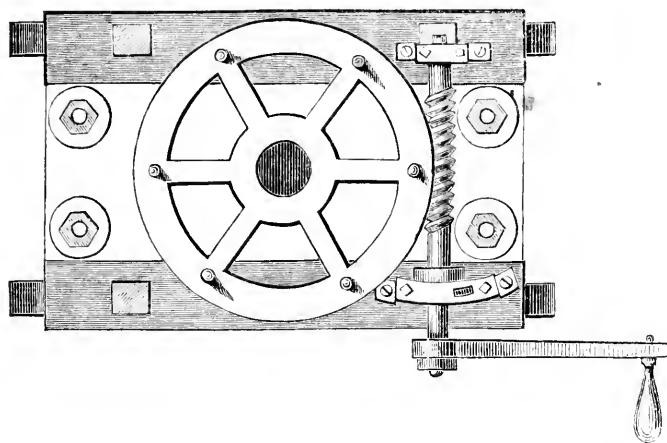
SINGLE-SCREW, OR VERTICAL PRESS.

this we must deduct the loss from friction. It will thus be seen, that, by a trifling addition to the mechanism of the machine, an immense increase of power may be gained. But in proportion as the power of

the press is increased, the strength of its different parts must be augmented. If it be intended to apply a pressure such as that above calculated, it will be necessary to replace the wooden screw and connecting pieces by those of iron, as indeed is represented in the drawing (fig. 241). It is also necessary to bear in mind, that with every increase of power gained by mechanical means there is necessarily a corresponding loss of time in accomplishing the required object.

With the press, fig. 242, the screw *a* makes but one revolution with each revolution of the cog-wheel; and to effect this, the endless screw, if it consist of a single thread, will require to be turned as many times as there are teeth to the cog-wheel. The process of screwing or unscrewing the press would, therefore, be a very slow and tedious one if there were not some means of performing it independently of the use of the handle *d d*. Such means, however, are provided, by which the screw can be turned more rapidly when the pressure is not applied. These consist in shifting the position of the endless screw, and then using the handles *p, p, p, p*, which afford sufficient power for merely raising or lowering the press-plates. The bolt (*t*) being removed, the endless screw and its socket is slipped back, so as no longer to be in gear with the cog-wheel, while the screw is turned expeditiously; and when the full force of the pressure

Fig. 243.



SECTION OF VERTICAL PRESS.

is required, they are restored to their original position, and the handle *d d* is used.

Fig. 243 is a vertical section of this press, in which the position of some of the parts is more clearly shown than in the preceding drawing.

[In the absence of a screw-press, a substitute may be found in what may be called a lever-press, and which almost any one may command. A piece of timber twelve feet long and with lateral dimensions sufficiently great to be inflexible with the force to be applied to it, has one of its ends securely attached to a wall or upright post in such a manner as to admit of the motion of the other end. The pressing-box being placed about one foot from the fixed end, on a firm block of wood, is subjected to the action of the lever, by placing a piece of wood vertically between the piston-block of the pressing-box and the lever. It is obvious, that a weight of one hundred pounds at the opposite end, causes a downward pressure equal to eleven hundred pounds at the box.

The pressing-box most usually employed by apothecaries, is a cylinder, closed at one end, made of thick tinned iron, secured with bands of the same material, which are soldered on, and between these, numerous holes are perforated. This cylinder is set in a tin dish, with a lateral spout. The piston-block is constructed of hard oak wood, with the grain running transversely to its axis.—W. P.]

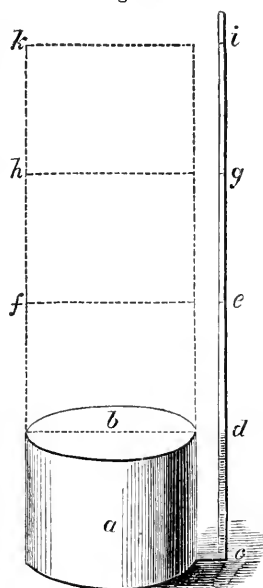
Bramah's Hydraulic Press, although hitherto but rarely employed in pharmaceutical laboratories, is nevertheless getting into more general use. The power obtained by a press of this description is much greater than that afforded by a screw-press occupying the same space, and this power is obtained at a smaller expense of labour. These advantages have determined a preference in favour of the hydraulic press, in cases where very great power is required, as, for instance, in the expression of fixed oils from seeds, &c.

The press itself consists of two cylinders, of unequal size, containing water, and connected together by a tube. The smaller cylinder is fitted up as a force-pump, while the larger one is provided with a solid piston, working through a water-tight collar. According to a well-known law of hydrostatics, any pressure applied by the piston of the force-pump is communicated through the liquid, equally, in every direction, and is exerted against the piston of the larger cylinder with an increase of power in proportion to the relative sizes of the two pistons.

The principle may be thus illustrated: *a*, fig. 244, represents a cylinder twelve inches in diameter, to which is attached a tube (*c, i*), a quarter of an inch in diameter, and forming, with the cylinder, an

inverted syphon. If the cylinder (*a*) be filled with water, the liquid will rise in the tube to the point *d*, thus standing at the same height in both limbs of the syphon. If, now, the top of the cylinder (*b*) be enclosed, and water poured into the tube until it rises to *e*, there will be a pressure exerted against *b* equal to the weight of the column of water (*d e*) multiplied by 2304, or the number of times the area of the tube is contained in that of the cylinder. Every additional increase in the column of water in the tube will cause an increase, in the above proportion, in the pressure against *b*; so that, when the water in the tube stands at *i*, the pressure against *b* will be that of the weight of a column of water having the area of the cylinder *a*, and the height of *k*. The force, in this case, is produced by the weight of the column of water *d i*; but the same effect would take place, if, instead of this column of water, pressure to the same extent were applied at *d* by means of a piston, or in any other way. The weight of the column of water *d i* is one ounce, and this is capable of producing a pressure against *b* equal to 2304 oz. If, instead of the weight of an ounce of water applied at *d*, pressure were applied there by a piston worked with a lever, as in the case of a pump, it would be easy to make the pressure at *d* equal to a ton, and then we should have a force exerted against *b* equal to 2304 tons.

Fig. 244.



In Bramah's hydraulic press the pressure is applied at *d* by the piston of a forcing-pump, and the accumulated force is made available at *b* by having there a movable piston working through a water-tight collar; so that, if the above proportions be maintained between the dimensions of the parts, a downward pressure of a ton, applied at *d*, will produce an upward pressure of about 2000 tons at *b*; the only deduction to be made from the theoretical increase of power being that for loss from friction.

The principle upon which this means of accumulating power is founded was well understood before Mr. Bramah so happily applied it in the construction of his press. The same principle is involved in Count Real's press, described in the chapter on SOLUTION. It may be thus expressed:—Pressure is exerted in liquids equally in every direction;

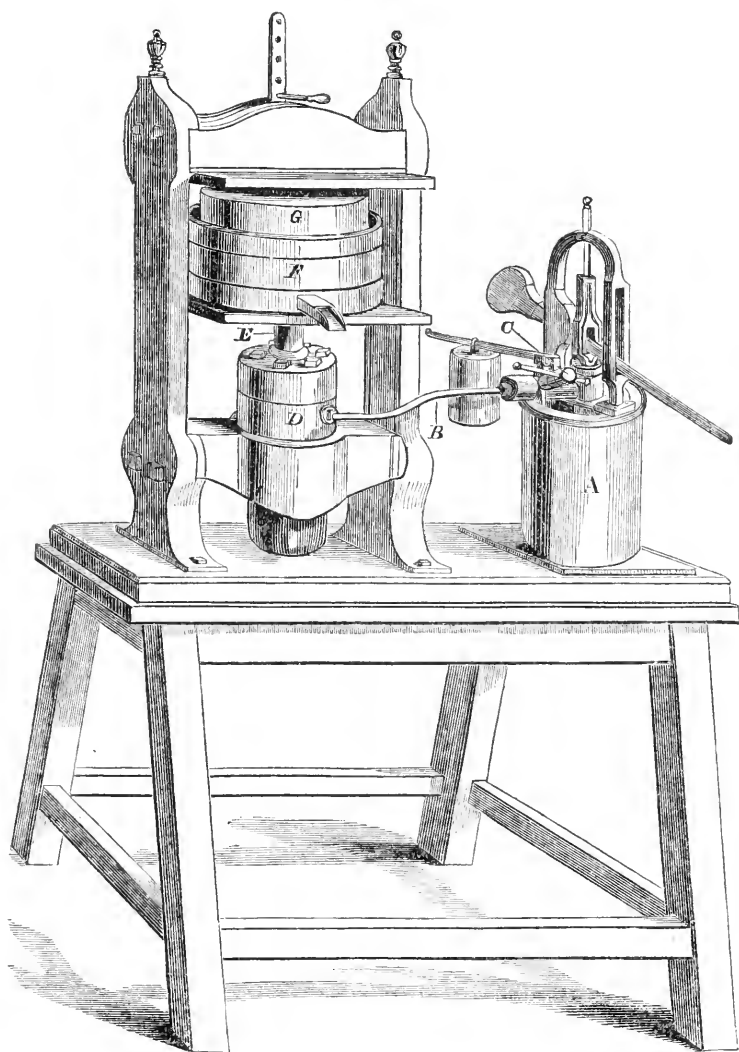
and the pressure which the bottom or sides of a vessel containing a liquid sustains will be in proportion to their extent of surface, and to the perpendicular height of the column of liquid above, without reference to the capacity of the vessel or the quantity of liquid it contains. Thus, the same pressure is exerted on the bottom of the cylinder *a*, (fig. 244.) when the water stands in the tube at *i*, as would be the case if the cylinder were extended to *k*, and filled with water.

Bramah's merit consisted in the application of a well-known principle for the economical production of immense power available for mechanical purposes. This application was made the subject of a patent in 1795, in the specification of which Mr. Bramah describes his press as a *hydra-mechanical engine*. But, although the application of the principle was secured by this patent, a difficulty was at first experienced in the construction of the machine, which greatly detracted from the value of the discovery. It was found impossible, by any means then known, to make the packing of the collar, through which the piston of the large cylinder of the press moves, so tight as to prevent the escape of water when the full pressure of the machine was applied, without at the same time rendering the piston immovable by the unaided power of the operator when the pressure was taken off. At length, however, a method of packing the piston was discovered by the original patentee, which completely removed this difficulty. This method consists in the use of a leather collar, the construction and application of which is as simple as the principle of its action is scientific; and so perfectly satisfactory is the effect of this contrivance, that it leaves nothing to be desired.

Fig. 245 represents a small hydraulic press, which I have been accustomed to use for several years. The framework of the press is made of cast iron, and it rests on a strong wooden stand. *A*, is a cistern containing water, in which is placed a small forcing-pump, worked by a lever handle, which may be lengthened when more power is required. This pump communicates with the strong cast iron cylinder (*D*), by means of the metallic tube (*B*). The piston (*E*), sometimes called the *ram*, moves through a water-tight collar, which is secured in its place by the cap of the cylinder; and, as the piston rises, it carries with it the iron plate, called the *follower*, on which the substance to be pressed is placed. The pressure is effected against the head of the press, where there is also another iron plate, which is supported there by a bolt secured above, as shown in the drawing. The forcing-pump is furnished with a safety-valve for controlling the pressure, and a valve for removing the pressure by

allowing the water to run back from the cylinder (D) into the cistern (A). These are shown at C.

Fig. 245.

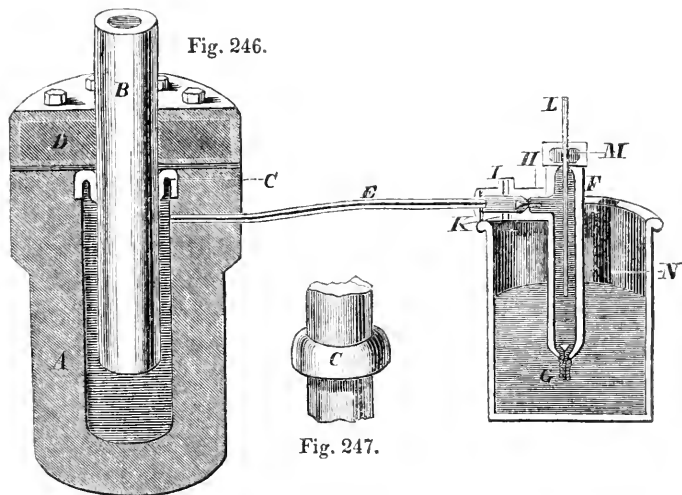


BRAMAH'S HYDRAULIC PRESS.

Fig. 246 will further illustrate the construction of some of the parts of this machine, which are here shown in section. N is the cistern of water; F, the cylinder of the forcing-pump; L, the piston of the pump, which is a solid rod working through a common stuffing-box

(M). G is the valve admitting water into the cylinder of the pump as the piston rises, but resisting its return into the cistern as the piston is depressed. H is the valve admitting water from the cylinder of the pump into the tube E when the piston is depressed, but resisting its return through the same channel. I is the opening closed by the safety-valve, which allows the escape of water when the pressure in the press exceeds that exerted by the weight attached to the valve. K is the opening for allowing the water to run out of the cylinder of the press when it is desired to remove the pressure, this being effected by unscrewing a plug that closes this opening. A is the strong cylinder of the press, into the cavity of which the solid piston or ram (B) passes. C is the leather collar, closely embracing the piston, and secured in its place by the cap (D), which is fastened with screws to the top of the cylinder. There is a depression in the top of the piston, into which a corresponding projection, attached to the bottom of the iron plate or follower, fits, so as to form the platform on which the press-box is placed, as shown in fig. 245.

A perspective view of the leather collar, with the piston passing through it, is shown in fig. 247; while C, fig. 246, shows it in sec-



SECTION OF HYDRAULIC PUMP.

tion. This collar is made of thick leather, and its peculiar form is given to it by pressing the leather, previously softened by immersion in water, into a circular groove, and afterwards cutting a hole in the centre to fit the piston.

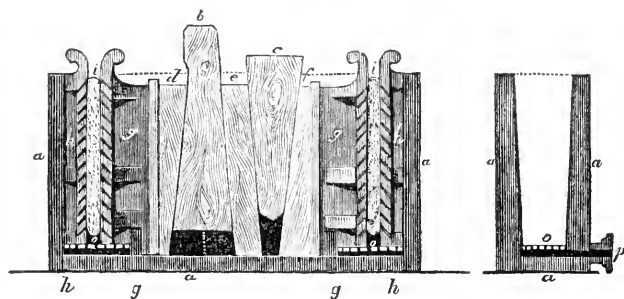
It will be seen, from the section, fig. 246, that the outer fold of the collar fits into a notch in the cylinder made for its reception, while the inner fold embraces the piston, to which its sharp edge fits closely on every side.

The great advantage of this kind of packing is, that the tightness with which the piston is embraced by the collar will be in proportion to the pressure of the water; for, in accordance with the principle already stated, that pressure in liquids is equal in all directions, the water filling the space between the two folds of the collar will exert a lateral pressure, which will always resist the passage of the liquid between the collar and the piston. This lateral pressure upon the folds of the collar, by which the packing is tightened, will increase with every increase of power applied to the press, and it will also decrease as soon as the power is removed, so that when the water is let off, the collar will relax the tightness of its grasp, and the piston (B) will descend into the cylinder by its own weight.

The piston (B, fig. 246) is frequently made of cast iron; and where the press is in constant use, this may probably answer very well; but under other circumstances it is objectionable, inasmuch as the iron becomes oxidised, and the piston does not then pass freely through the collar. I have found it necessary to have the iron piston, which my press originally had, replaced by one made of gun-metal, and since this substitution it has never got out of order.

A manufacturer of these presses states, that the lowest price at which a press, such as that I have described, and of a suitable size for pharmaceutical purposes, could be made, would be from twenty to thirty guineas.

Fig. 248.



[“Where expense is not so much an object, Bramah’s press is decidedly to be preferred; in other cases, and generally indeed (for expressing the fixed oils) a wedge-press is employed, which works as

powerfully, although not with so much ease, and with much more noise. The filled cloths are laid between strong plates, *h* and *g*, and placed in a square space cut in a solid block of oak wood, or as in fig. 248, in a cast iron case *a*, and the plates are forced nearer and nearer to each other, by driving in the wooden wedges which occupy the remaining space. One of these wedges, *b*, serves to facilitate the disconnexion of the apparatus; the strokes which drive in the wedge *e*, tending from the reverse position of *b* to drive it out; *f* *e* and *d* are intermediate pieces, to prevent the wedges from coming into immediate contact. The pressing plates are each provided with three side ribs; the immovable ones *h h* press against the sides of the case, and the movable ones *g g* against the intermediate wedges *d f*, and they are pierced with numerous holes, to allow the oil to flow out more easily. On filling the press, the wedge *b* must be suspended (by a string) at a distance (*a*) from the bottom, that the apparatus may be easily taken to pieces. The oil trickles from the pressing plates through the pierced horizontal plates *o o*, upon which these rest, into the pipe *p*. Both *b* and *e* are driven by separate stampers, which are raised by a toothed wheel."—*Knapp's Technology*, vol. i. p. 116.—W. P.]

THE PROCESS OF EXPRESSION.

In using any one of the presses here described, some means are frequently required, beyond those hitherto noticed, for confining the solid part of the substance to be pressed during the process of expression. When a press-box, such as that figured at page 222, is employed, the substance is not unfrequently put directly into the inner case of the box, without anything intervening; sometimes, however, the substance is enclosed in a *press-cloth* or *bag*, previously to its introduction into the box, and there are cases in which this method of operating is necessary.

The *tincture-presses* most commonly used by pharmacutists who operate upon small quantities of ingredients at a time, are constructed with a view to their employment without a press-cloth or bag, or at least, with such only as shall act as a strainer, it being important in these cases to avoid using a thick cloth or bag, which would cause loss by absorbing part of the liquor.

It is customary with large presses to use a press-cloth or bag, and this practice is adopted even with small presses, when the substance to be pressed is of a pulpy nature.

The bags and cloths used for this purpose are made of different materials, the object being to have them sufficiently strong to bear the force exerted laterally during the process of expression, while at the same time they are not so thick or porous as to absorb much of the liquid.

Press-bags are very commonly made of horse-hair cloth, a material which possesses great strength and durability; and, although this cloth is necessarily rather thick, yet it does not absorb liquids to so great an extent as cloth made of ligneous fibre, or even of wool. A horse-hair bag, after having been used, may, therefore, be more completely freed from any impregnation of the substance operated upon, than the other kinds of straining cloth.

The principal objections to the horse-hair cloth are, that it is always coarse, thick, and stiff. It appears that the strong hair employed in making it, cannot be manufactured, or, at least, is not manufactured, into fine and flexible cloth. This cloth, therefore, can only be used advantageously in the form of a bag, and it is inapplicable even for a *small bag*.

Strong canvass, or *unbleached linen cloth*, is sometimes substituted for horse-hair, but it is inferior in every respect, excepting in regard to the closeness of its texture and its flexibility; in these respects it is better adapted for operations on a small scale.

Woollen cloth is manufactured with a view to its application in the process of expression, and is sold for this purpose by the dealers in straining-cloths, sieves, and other articles of this kind used by druggists. This is the material generally employed in the expression of fixed oils, such as castor-oil, oil of almonds, &c. The seeds from which these oils are pressed, are first crushed by passing them between two cylinders turning in opposite directions, and placed nearly in contact with each other, the distance being regulated so as to produce the required degree of disintegration. The crushed seeds are then folded in square pieces of the woollen press-cloth, so as to form flattened cakes; and a number of these are placed one over another, with intervening plates of tin or tinned copper, forming a pile between the follower and the head-plate of the press.

In conducting the process of expression, the substance to be pressed being confined in the manner best suited to the circumstances of the case, the pressure must be *gradually applied*. If the substance be in a soft and pulpy state, it will be necessary to begin with a very slight pressure, for as the force applied will, in this case, be communicated equally in every direction, according to the law of hydrostatics, the

bag or cloth would inevitably give way, or the substance escape through the apertures intended for the flow of the liquid, if much force were exerted. When part of the liquid has been pressed out, and the remaining substance has become more firm, increased pressure may be applied, and ultimately, as the contents of the bag become solid, the full force of the press may be safely exerted.

The effect of applying pressure in this way, to a substance consisting of solid and liquid particles, is to cause the nearer approach of the former to each other, while the latter are displaced and forced out through the apertures provided for this purpose. Much force is required to overcome the resistance offered by the pressure of the liquid, and also by the elasticity of the solid particles themselves. Great compression cannot be effected suddenly, with the means usually resorted to, continued application of the pressure for some time being necessary, so that the solid particles may approach nearer and nearer as the elasticity by which they were kept apart is gradually overcome and destroyed. Thus, after effecting as much compression as the means provided will admit at one effort, if the press with its contents be left unrelaxed for a few minutes, it will be found at the expiration of this time, that further compression may be effected by the renewed application of the same power. It is by following up the effects in this way, with intervals of cessation in the application of new force, that the required object is ultimately attained.

To accomplish the object efficiently by these means, it is necessary that the press should be capable of maintaining unrelaxed the degree of compression which has been produced at each successive effort, and that it should not allow the particles by their elastic force, to regain, to any extent, their original condition. This quality is possessed to a greater extent by the *screw-press* than by the *hydraulic-press*. The former will maintain for an indefinite length of time any degree of compression which may have been given to the substance placed in it; but not so the latter. The pressure in the hydraulic-press, being communicated through a liquid, and maintained by the action of valves, it is found practically impossible, with the kind of skill usually bestowed in the manufacture of these presses, to prevent a slight leakage, which causes a relaxation of the pressure when the pump is not in action. It is necessary, therefore, more frequently to renew the force in conducting the process of expression with the hydraulic-press, than is the case with the screw-press.

CHAPTER IX.

SOLUTION, AND THE METHODS OF OBTAINING SOLUTIONS, FOR SYRUPS, EXTRACTS, TINCTURES, WINES, VINEGARS, ETC.

[SOLUTION may be described as that operation in which a solid body, placed in contact with a liquid, disappears or takes on the fluid state, and becomes intimately mixed with the liquid. The liquid is called a *solvent*, or *menstruum*. Solution is not confined to solids, as fluid and gaseous substances may dissolve in liquids.

Two kinds of solution have been recognised:—

1. Where the dissolved body retains its sensible and chemical properties, except those that depend on aggregation, and is recoverable by evaporation; as solutions of sugar, and of salts in water.

2. Where chemical reaction takes place between the particles of the solvent and those of the dissolved body, but for which solution would not have taken place, and after which the properties of both have been modified by the loss or acquisition of properties. The solution of metals in nitric acid is an example.

Solution being in direct opposition to cohesion, the aggregative attraction has to be overcome;—consequently, mechanical division facilitates solution, by increasing the extent of surface.

All aqueous solutions of solid bodies being denser than water, when a soluble substance is suspended in a liquid, the parts in contact with the substance become denser than the adjacent fluid, and cause downward currents.

Heat favours solubility, by increasing the capacity or solvent power of the liquid, and also by the currents which it establishes.

A solution is said to be saturated, when it ceases to dissolve more of a substance at the common temperature; and the nearer the point of saturation, the more tardily is the process effected.

Any cause that retards evaporation, favours the accumulation of

temperature, in heating liquids, and saves menstruum; flasks are, therefore, very proper when adhesion does not occur. When a capsule is more appropriate, it may be covered with a large one, or with a glass funnel rather smaller in diameter than the dish, which renders it, for the time being, a flask.

A saturated solution of one salt is a solvent for other salts, a fact that is largely applied in the purification of nitre, by causing a saturated solution of that salt to filter through powdered nitre, which dissolves out the contaminating salts. Carbonate of potash, and other pharmaceutical salts, may be thus purified.

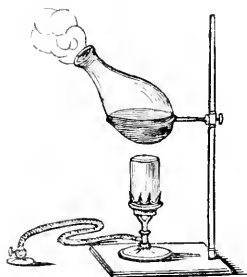
Rapid solution, when not accompanied by chemical action, always causes a reduction of temperature in the liquid, owing to the increased capacity of the solid for heat, by the assumption of the liquid state; and decreases its solvent power. One advantage of heat in effecting solution, is to counteract this tendency.

When solution is accompanied by chemical reaction, the phenomena of effervescence, heat, and change of colour, odour, and taste, often attend it.

In this kind of solution, the important points requiring attention are, the degree of division of the substance to be dissolved, if solid, the concentration of the solvent, and the temperature at which the solution is effected; as by the degrees of these, the reaction is increased or diminished.

When solution is accompanied by effervescence, if in a flask, the neck should be inclined at an angle of 45° , as in fig. 249, so that the particles of liquid carried up may strike against the side of the flask, and be returned. If the operation is performed in a capsule, it should either be covered with a funnel, with a plate of glass, or with a larger capsule, the bottom of which is clean. A retort and receiver may be used, in those cases where the dissolved substance has to be repeatedly digested with nitric acid; as in converting phosphorus into phosphoric acid, when the acid that distils over is returned.

Fig. 249.



Pharmaceutical menstrua.—The liquids chiefly used in pharmacy as solvents are water, alcohol, ether, wine, vinegar, and the fixed and volatile oils. But the acid and alkaline solutions are resorted to, in

various of the processes of pharmaceutical chemistry. Each of the first-named liquids, gives rise to one or more classes of preparations, as infusions, decoctions, tinctures, wines, vinegars, &c.

Water, the grand solvent of nature of the ancients, has a more extensive range than any other liquid. A great number of mineral salts, nearly all the salts of the vegetable alkalies, most of the neutral principles, as gum, sugar, &c., and the vegetable acids, are dissolved by it. Many organic substances, insoluble in an isolated state, become so by virtue of associated ingredients, as cantharidin, columbin, some resins, &c.

Alcohol, though less extensive in its solvent power than water, far exceeds any other neutral liquid, especially for organic substances. The resins, volatile oils, organic alkalies, and many neutral principles, are very soluble in it, and its antiseptic quality has caused it to be employed as the liquid basis of an extensive class of preparations,—the tinctures. Besides, it possesses the valuable negative quality of not dissolving gum, albumen, and starch, which are so destructive to the permanency of aqueous solutions.

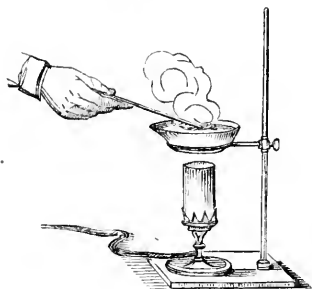
Ether possesses a much more limited range than either of the preceding. The fixed and volatile oils, fats, and resins, are the chief subjects of its solvent power, but a few mineral salts, several vegetable alkalies, as quinia, còcchia, and narcotina, and some neutral principles, are also dissolved by it.

MODES OF SOLUTION.—Two grand divisions of substances are submitted to the action of fluids, viz.:—those which are homogeneous, and dissolve entirely in the menstruum,—as salts, resins, gums, &c.; and those which are only partially soluble, being composed of various principles, as plants of all kinds, and their parts. The first yield simple solutions, the second, infusions, decoctions, tinctures, &c.

In preparing simple solutions, with cold liquids, if the amount of substance is near the capacity of the liquid, it should be reduced to powder in a mortar and a portion of the liquid triturated with it, and when this is saturated, pour off the solution, add more liquid, and proceed in this manner until all is dissolved. Tincture of iodine may be instanced.

When heat is necessary, and a flask is used, one should be chosen that the liquid will fill at least to its greatest diameter; or if this is not convenient, a ring of sheet iron should be used to protect the glass, above the liquid, from the influence of the heat. When solution takes place tardily, and a lengthy ebullition is required, in replacing

Fig. 250.



the evaporated fluid, beware of cracking the flask by a sudden effusion of cold liquid on its sides. When the substance softens before dissolving, as extracts, tartrate of iron and potassa, &c., the process should be conducted in capsules, and stirred constantly to prevent adhesion, as in fig. 250, especially if the heat is direct. The sand or water bath is to be preferred. A flask of liquid on the point of boiling over, may be checked, by blowing rapidly on the upper surface, and neck, until the source of heat can be removed; and a kettle of syrup under the same circumstances, is best saved from loss by an effusion of cold water, or by fanning its surface.

When the quantity of matter to be dissolved is large, and the time admits, the process of *circulatory displacement* is best resorted to. This consists in taking advantage of the law, that solutions of solids are heavier than their solvents, by placing the substance to be dissolved on a diaphragm just below the surface of the liquid. The solutions of sulphate of iron and carbonate of soda, for making Vallett's carbonate of iron, and those for phosphate of iron and acetate of zinc, may be thus obtained,—the salts being suspended in a loose-textured cloth. This principle is largely applied in the arts in the manufacture of saltpetre, carbonate of soda, &c., and is the same involved in the method of Mr. Alsop for infusions, and that of Dr. Burton for tinctures, to be noticed hereafter.

The manner of effecting this in the soda manufacture is shown in fig. 251. Each of the iron lixiviating cisterns, A, A, is divided by a double partition, and the two halves are connected by an aperture *a*, at the bottom, and another, *b*, at the top. In each compartment there are two sheet-iron boxes, *n*, *n*, pierced with holes in their sides and bottom like a sieve. These are filled with crude soda, and suspended just below the surface of the water. As the dense solution collects at the bottom, it is driven over into the other apartment, through *a* and *b*, to be further saturated—when it passes from the first to the second vessel in the same manner by the tubes *g g*, where a yet further solution takes place, and so on to the lowest cistern, of which there are ten or twelve, when the water is saturated. The fall of temperature, caused by the solution of the saline matter,

is counteracted by the steam-pipes *h* A.—*Knapp's Technology*, vol. i. p. 275.

Fig. 251.

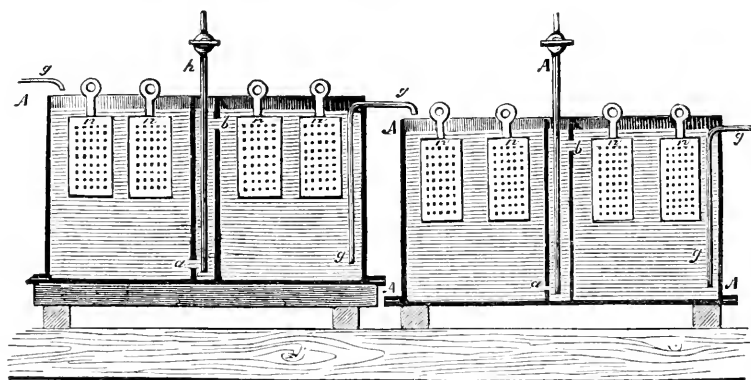


TABLE OF SOLUBILITIES.

The following table of solubilities has been compiled chiefly from a table of the same kind in the “*Pharmacopée Raisonnée*” of Henry and Guibourt. Additions have been made from other sources, especially from Brande. In selecting the substances, a view has been turned to the wants of the pharmaceutist, and an innumerable list of salts, which are rarely seen and never used, have been excluded from the catalogue here presented. The use of this table is obvious:—Physicians sometimes direct saturated solutions without specifying the proportion of matter to the solvent; in such a case, reference to the table will save time and trouble, by indicating the proper quantity of each. In preparing saline solutions for precipitation, the smallest proportion of menstruum that can be used is at once shown by the table. In most instances, there are two temperatures indicated in the second column. The third exhibits the ratio of solvent to the dissolved body, and is that part of the table most useful in practice. The fourth column shows the proportion of solid in a given weight of a saturated solution, and will enable the operator to arrive at a satisfactory judgment of the quantity of saline matter in a solution, where he has not previously ascertained it by weighing. The last division of the table presents a view of the solubility in alcohol, and in some instances in ether, of many of the substances.

TABLE OF SOLUBILITIES.

NAMES OF SUBSTANCES.	Tempera- ture of the solvent.	Quantity of water neces- sary to dis- solve 1 part of substance.	Quantity of substance contained in 100 parts of saturated aqueous so- lution.	Solubility in alcohol.
ACIDS.				
Acid, arsenious, (transparent,)	59°	103.	0.96	
" " "	Boiling.*	9.33	9.68	
" " (opaque),	59°	80.	1.25	
" " "	Boiling.	7.72	11.47	
" " "	After } cooling. }		2.90	
" Arsenic,	59°	6.	15.	
" Benzoic, (crystallized,)	Cold.†	200.	0.50	Very soluble.
" " "	212°	30.	3.25	
" Boracic, "	68°	25.66	3.75	Soluble.
" " "	Boiling.	2.97	25.18	
" Citric,	Cold.	0.75	57.14	Soluble.
" " "	Boiling.	0.50	66.66	More soluble.
" Gallic,	Cold.	20.	4.76	Very soluble.
" " "	212°	3.	25.	
" Malic,	Cold.	very	soluble.	Very soluble.
" Oxalic,	59°	8.7†	10.31	Soluble.
" Paratartaric,	59°	57.5	17.39	} Less soluble than in water.
" Phosphoric,	59°	very	soluble.	
" Succinic,	Cold.	25.	3.85	Soluble.
" " "	Boiling.	3.	25.	Very soluble.
" Tartaric,	60°	4.	20.	Soluble.
" " "	Boiling.	0.50	66.66	
" Valerianic,	55°	30.	3.22	Very soluble.
SALIFIABLE BASES.				
Aconitia,	Cold.	150.	0.66	} Soluble readily in alcohol and in ether.
" "	Boiling.	50.	2.	
Atropia,	Cold.	500.	.20	} Soluble in anhy- drous alcohol and in ether.
Baryta, (anhydrous,)	50°	20.	4.76	
" " (hydrate of,)	Boiling.	10.	9.09	Insoluble.
" " "	"	3.	32.	
Brucia,	Cold.	850.		} Soluble in anhy- drous alcohol.
" " "	212°	500.		
Cinchonia,	Cold.	7000.		Soluble.
" " "	Boiling.	2500.		More soluble.
Codeia,	Cold.	80.	1.25	} Soluble; and very soluble in ether.
" " "	Boiling.	87.	5.50	
Conia,	Cold.	Sparingly	soluble.	} Very soluble, and in ether, the fixed and volatile oils.
Daturia,	"	280.	0.36	
" " "	212°	72.	1.25	Very soluble.
Emetia,	Cold.	Sparingly	soluble.	} Very soluble in al- cohol and in ether.
Hyoscyamia,	"	500.	.20	
Lime,	59°	778.	0.128	Soluble.
				Insoluble.

* The term "boiling" is intended to mean the boiling point of the solution.

† The solubility determined at the ordinary temperature of the air.

‡ The pure acid. When a little nitric acid is present, oxalic acid is more soluble than indicated.

NAMES OF SUBSTANCES.	Tempera- ture of the solvent.	Quantity of water neces- sary to dis- solve 1 part of substance.	Quantity of substance contained in 100 parts of saturated aqueous so- lution.	Solubility in alcohol.
Lime,	212°	1270.	0.079	Insoluble. 40 parts (absolute.) 30 " " Very soluble. Very soluble. Very soluble. Very soluble. Insoluble in anhy- drous alcohol; solu- ble in alcohol, sp. gr. .835.
Magnesia,	59°	5142.		
"	212°	36000.		
Morphia,	Cold.	Nearly	insoluble.	
"	Boiling.	100.	1.	
Nicotina,	Cold.	Very	soluble.	
Potassa,	60°	0.50	66.66	
Quinia,	Cold.	Nearly	insoluble.	
"	212°	200.	0.50	
Soda,	Cold.	Very	soluble.	
Strontia, (anhydrous,)	50°	40.	2.44	
"	212°	20.	4.76	
" (hydrated,)	59°	52.	1.80	
"	Boiling.	2.	33.33	
Strychnia,	Cold.	6667.		
"	212°	2500.		
NEUTRAL ORGANIC PRINCIPLES.				
Digitalin,	Cold.	2000.	.05	
Piperin,	"	Insoluble.		Readily soluble.
Salicin,	60°	20.	5.	Same as in water.
"	Boiling.	Very	soluble.	
Asparagin,	Cold.	58.	1.7	Insoluble.
Caffein,	"	3.	25.	Readily soluble.
Sugar,	"	.50	66.66	24½ parts alch.: 830.
Camphor,	"	150.	} By aid of magnesia.	100 pts. sp. gr. 806,
Gum, (Arabic,)	"	1.		50.
SALINE COMPOUNDS.				
Acetate of ammonia,	Cold.	Very	soluble.	Soluble.
" baryta,	"	1.75	36.36	
"	Boiling.	1.	50.	
" lime,	Cold.	Soluble.		Soluble.
" copper, (cryst'd,)	Boiling.	5.	16.	Sparingly soluble.
" mercury, (bi,)	Cold.	2.75	26.66	Soluble.
"	212°	In part	decomposed	
" " (proto,)	Cold.	600.		Insoluble.
" iron,	"	Soluble.		Soluble.
" morphia,	"	Very	soluble.	Soluble.
" lead, (cryst'd,)	"	1.63	37.	8 parts.
" quinia,	"	Moderately	soluble.	Soluble.
" potassa,	60°	1.	50.	In 2 parts.
" soda, (cryst'd,)	Cold.	2.86	25.91	Soluble.
" zinc,	"	Very	soluble.	
Arsenate of potassa,	40°	5.3	18.	Insoluble.
" soda,	Cold.	Very	soluble.	
Arsenite of quinia,	Cold.	Sparingly	soluble.	Soluble at 176° F.
" potassa,	Cold.	Very	soluble.	
Borate of soda, (bi,)	"	12.	9.23	
"	222°	2.	33.33	
Bromide of potassium,	Cold.	Very	soluble.	Slightly soluble.
" sodium,	"	Very	soluble.	Soluble.
Carbonate of ammonia, (sesqui)	60°	2.	33.33	
"	Boiling.	1.	50.	
" baryta, lime, lead,	Cold.	Insoluble.	52.	Insoluble.
" magnesia & zinc,				
" potassa, (dry,)				

NAMES OF SUBSTANCES.	Tempera- ture of the solvent.	Quantity of water neces- sary to dis- solve 1 part of substance.	Quantity of substance contained in 100 parts of saturated aqueous so- lution.	Solubility in alcohol.
Carbonate of potassa, (bi,)	Cold.	4.	20.	1200 parts.
" " "	Boiling.	1.2	41.6	
" soda,	Cold.	2.	33.33	
" " "	22°	1.	50.	
" " (bi,)	Cold.	13.	7.14	
" " "	Boiling.	Decomposed.		
Chlorate of potassa,	32°	30.03	3.22	Slightly.
" "	56°	17.85	5.30	
" "	220°	1.66	37.59	
Chloride of antimony, (proto,)		Decomposed.		
" barium, (cryst'd,)	60°	2.3	30.20	
" " "	222°	1.28	43.22	Very soluble.
" " (anhydrous,)	60°	2.86	25.84	
" " "	222°	1.67	37.33	
" bismuth,		Decomposed.		
" calcium,	32°	0.50	66.66	
" " "	60°	0.25	80.	{ Very soluble, and in ether.
" " "	Boiling.	Extremely	soluble.	
" gold,	Cold.	Very	soluble.	
" " and sodium,	"	Very	soluble.	
" iron, (sesqui,)	"	Very	soluble.	
" " (proto,)	"	Very	soluble.	{ More soluble in al- cohol and ether than in water.
" mercury, (proto,)		Insoluble.		
" " (bi,)	50°	18.23	5.2	
" " "	212°	3.	25.	
" lead,	Cold.	30.	3.22	
" " "	212°	22.	4.35	Very soluble.
" platinum,	Cold.	Very	soluble.	
" " & potassium,	"	Very slightly	soluble.	
" " & sodium,	"	Very	soluble.	
" " & ammonia,	"	Very slightly	soluble.	
" potassium,	59°	3.	25.	{ Soluble in aqueous alcohol.
" " "	230°	1.68	37.2	
" sodium,	57°	2.79	26.36	
" " "	Boiling.	Same as	cold.	
" zine,	Cold.	Very	soluble.	
Chlorohydrate of ammonia,				Soluble.
(sal ammoniac,)	"	2.72	26.88	
" " "	Boiling.	1.	50.	
" morphia,	Cold.	16. to 20.		
" quinia,	"	{ More soluble than the sulphate.	{	
" strychnia,	"	Very	soluble.	Soluble.
Chromate of potassa,	59°	2.06	32.66	Insoluble.
" " (bi,)	59°	10.	9.09	Insoluble.
Citrate of ammonia,	Cold.	Very	soluble.	Insoluble.
" iron, (proto,)	"	Soluble.		Insoluble.
" " (per,)	"	{ Very soluble in hot water, and the salt re- mains in solution when cold: sparingly in cold water direct.	{	Insoluble.
" " and ammonia,	"	Very	soluble.	Insoluble.
" " and quinia,	"	Soluble.		Insoluble.
" lime,	"	Insoluble.		

NAMES OF SUBSTANCES.	Temperature of the solvent.	Quantity of water necessary to dissolve 1 part of substance.	Quantity of substance contained in 100 parts of saturated aqueous solution.	Solubility in alcohol.
Citrate of magnesia, (neutral),	Cold.	Sparingly	soluble.	
“ “ (acid),	“	Much more	soluble.	
“ potassa, (neutral),	“	Very	soluble.	Insoluble.
“ quinia,	“	Sparingly	soluble.	Soluble.
“ soda,	“	Very	soluble.	Insoluble.
Cyanide of silver,	“	Insoluble.		
“ mercury, (bi),	60°	8.	12.	Sparingly.
“ potassium,	60°	Very	soluble.	Sparingly.
“ ferro-potassium,	59°	3.	25.	
“ “ “	Boiling.	1.	50.	
“ ferrid. “	Cold.	38.	2.56	
Iodate of lime,	“	400.	0.25	
“ “	212°	100.	0.99	
“ potassa,	56°	13.45	6.92	Insoluble.
“ soda,	56°	13.70	6.80	Insoluble.
Iodo-hydrate of ammonia,	“	Very	soluble.	
“ strychnia,	“	Insoluble.		
Iodide of barium,	Cold.	Very	soluble.	Soluble.
“ calcium,	“	Very	soluble.	
“ iron, (proto),	“	Very	soluble.	Soluble.
“ lead,	“	579.	0.17	
“ “	Boiling.	254.	0.39	
“ mercury, (proto),	Cold.	Very	slightly.	
“ “ (bi),	Boiling.	Sensibly	soluble.	Sparingly soluble.
“ potassium,	Cold.	1.	50.	Soluble.
“ zinc,	“	Very	soluble.	
Nitrate of ammonia,	“	2.	33.33	Very soluble.
“ “	Boiling.	1.	50.	
“ baryta,	32°	20.	4.76	
“ “	59°	12.22	7.56	
“ “	Boiling.	2.84	26.02	
“ lead,	Cold.	7.50	11.77	
“ lime, (cryst'd),	“	0.25	80.	{ Soluble in one part boiling.
“ “	Boiling.	Extremely	soluble.	
“ mercury, (proto),	Cold.	Decomposed.		
“ “ (bi),	“	Decomposed.		
“ potassa,	32°	7.51	11.72	{ Insoluble in anhy- drous alcohol.
“ “	41°	5.98	14.33	
“ “	53°	4.50	18.18	
“ “	64°	3.41	22.66	
“ “	76°	2.60	27.74	
“ “	207°	0.42	70.28	
“ magnesia,	Cold.	Very	soluble.	Soluble.
“ soda,	21°	1.55	38.68	Soluble.
“ “	32°	1.25	44.44	
“ “	50°	4.40	18.50	
“ “	60°	1.82	35.48	
“ “	246°	0.46	68.60	
“ strontian,	Cold.	5.	16.66	
“ “	Boiling.	0.5	66.66	
“ silver,	Cold.	1.	50.	In 4 parts.
Oxalate of ammonia,	“	22.2	4.5	Insoluble.
“ potassa,	“	3.	25.	Slightly.
“ “ (bi),	“	40.	2.5	{ Sparingly.
“ “ “	Boiling.	6.	16.	
“ lime,	Cold.	Insoluble.		
Phosphate of ammonia, (neu'l),	“	4.	20.	Soluble.
“ “ (acid),	“	5.	16.66	

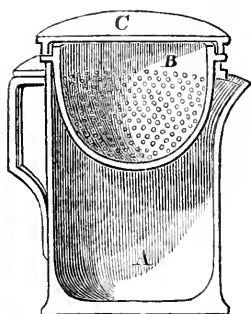
NAMES OF SUBSTANCES.	Temperature of the solvent.	Quantity of water necessary to dissolve 1 part of substance.	Quantity of substance contained in 100 parts of saturated aqueous solution.	Solubility in alcohol.
Phosphate of ammonia and magnesia,		Nearly	insoluble.	
" magnesia,	Cold.	15·	6·25	
" "	Boiling.	Decomposed.		
" soda, (rhombic),	Cold.	4·	20·	
" "	Boiling.	2·	33·33	
Sulphate of alumina,	Cold.	2·	33·33	
" alumina and potassa, (alum),	"	18·36	5·16	Insoluble.
" alumina and potassa,	Boiling.	0·75	57·14	
" alumina and soda,	60°	0·909	52·38	
" antimony,	60°	Decomposed.		
" ammonia,	60°	2·	33·33	
" "	212°	1·	50·	
" cinchonia,	57°	0·46	68·49	{ Soluble in one part of anhydrous alcohol.
" "	212°	Very soluble.		
" copper,	Cold.	4·	20·	
" "	Boiling.	2·	33·33	
" iron, proto, (cryst.)	Cold.	2·	33·33	Insoluble.
" "	Boiling.	0·75	57·14	
" lime,	Cold.	500·	0·2	
" "	212°	450·	0·202	
" magnesia, (cryst.)	58°	0·96	50·90	
" "	207°	0·155	86·56	
" " anhydrous,	58°	3·05	24·67	
" "	207°	1·38	41·96	
" manganese,	Cold.	2·50	28·57	Insoluble.
" mercury,	"	Decomposed.		
" morphia,	"	2·	33·33	
" potassa,	54°	9·46	9·56	Insoluble.
" "	Boiling.	3·80	20·84	
" quinia, (di),	Cold.	740·	1·36	80 parts.
" "	Boiling.	30·	3·25	More soluble.
" " neutral,	Cold.	Very	soluble.	Very soluble.
" soda, (anhydrous),	32°	19·92	4·78	
" " "	52°	9·88	9·19	
" " "	90°	1·97	33·62	
" " "	220°	2·34	29·90	
" " crystallized,	32°	8·22	10·84	
" " "	52°	3·79	20·87	
" " "	90°	0·31	76·31	
" strontia,	Cold.	3840·	·0026	
" silver,	"	Nearly	insoluble.	
" "	212°	88·	1·2	
" strychnia,	Cold.	10·	9·1	
" zinc,	"	2·50	28·57	Insoluble.
Tartrate of iron, (proto),	"	426· ?	·925	
" " (per),	"	Very	soluble.	Insoluble.
" " and ammonia,	"	4·	20·	Insoluble.
" " and potassa,	"	4·	20·	Insoluble.
" potassa,	"	4·	20·	
" " "	238°	Extremely	soluble.	
" " (bi),	Cold.	95·	1·04	
" " "	Boiling.	15·	6·25	
" " and soda,	Cold.	2·5	28·57	
" " and antimony,	"	14·	6·66	
" " (tartar emetic)	Boiling.	1·88	34·72	
" soda,	Cold.	8·	12·	
" "	Boiling.	1·8	55·5	

Maceration consists in subjecting a complex substance, composed of soluble and insoluble matter, in a divided state, to the action of fluids at the common temperature, for a greater or less period of time, until the soluble part has been ceded to the liquid; and is applied in making tinctures, wines, and some infusions.

Infusion is the solvent action exercised on drugs by water at the boiling temperature, during the time occupied in cooling, or for a specific time. The solution so obtained is called an *infusion*. The process is varied as to the time being longer or shorter in reference to the ready extractibility of the principles sought to be dissolved. The process should be performed in close vessels, and when small quantities are required, thin glass bottles form an excellent receptacle, as they may be corked, and are easily shaken at intervals.—W. P.]

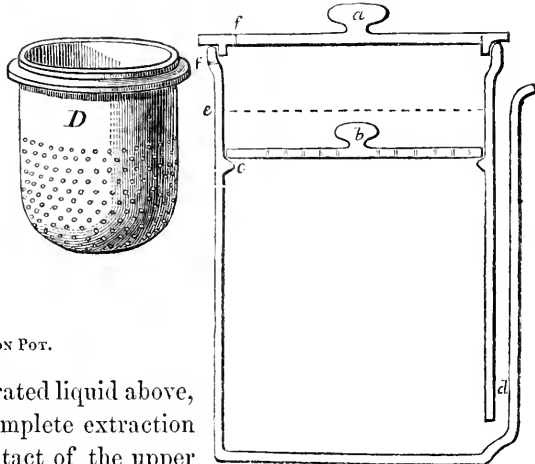
Fig. 252 represents a very good form of *infusion pot*, which has been introduced by Mr. Squire, of Oxford Street. It is constructed on the principle originally suggested by Mr. Alsop, which consists in retaining the solid substances to be infused in the upper part of the vessel, instead of allowing them to subside to the bottom. Mr. Alsop observed that when infusions were made in the latter, which is the usual way, the water in contact with the solid ingredients became saturated, or highly charged with soluble matter, and thus formed a dense stratum at the bottom, which had little tendency to diffuse

Fig. 252.



SQUIRE'S INFUSION POT.

Fig. 253.



SECTION OF ALSOP'S INFUSION MUG.

itself into the less saturated liquid above, and thus prevented complete extraction by cutting off the contact of the upper stratum of the liquid with the substance to be acted upon. Mr. Alsop proposed having a perforated diaphragm, as at *b*, Fig. 253, one-third way from the top of the pot, on which to

place the solid ingredients. For this, Mr. Squire has substituted the perforated dish B, or D, fig. 252, which answers the twofold purpose of supporting the solid substances in the upper part of the liquid, and of straining the infusion, when it has stood long enough, by merely lifting this out. The angles within and without the pot are rounded off, whenever this is practicable, so that the vessel may be the more easily kept clean.

[Water is the only menstruum used in making infusions, though alcohol is sometimes added to them to give them permanency, as in the compound infusion of gentian, of the U. S. Pharmacopœia.

Digestion differs from maceration only in the temperature employed, it being constant during the operation, and may extend from 100° to 200° Fahr. Substances of close impenetrable texture are thus treated before being boiled or displaced, and all the pharmaceutic menstrea excepting wine are subjects of this process. Starch is digested with solution of malt at the temperature of 150° Fahr., in making dextrine, in order that the diastase, which would be rendered inert by ebullition,

Fig. 254.

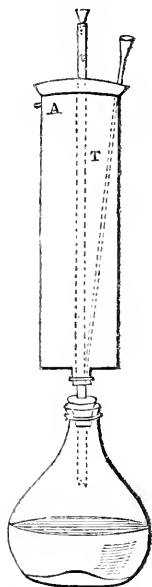
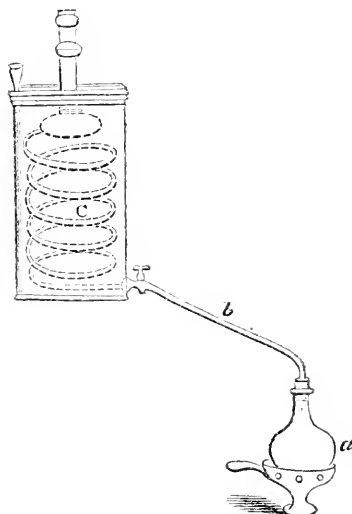


Fig. 255.



may have time to act. Infusion, when conducted in the Biendorf apparatus, as directed by the Prussian Pharmacopœia, is an instance of digestion. When alcohol and ether are used in the process of digestion, some means should be resorted to to prevent their loss. If the process is conducted in a retort and receiver, it involves the neces-

sity of returning the distilled portion from time to time. MM. Berthamot and Carriol have suggested an arrangement consisting of a wide-mouthed flask, surmounted by a glass vessel containing a worm of the same material, which communicates with the flask. The worm is surrounded with cold water, and as the vapour of ether rises, it is condensed, and runs back into the flask. M. Soubeiran has simplified this by attaching the tube of a small condensing worm, of lead or tin, to a common flask by means of a tube passing through a cork, as at *b*, fig. 255, and Mohr has invented a yet more simple arrangement, which consists of a glass tube, T, fig. 254, passing through a tin cylinder A, which is kept filled with cool water by the small funnel tube. The glass tube enters the mouth of the digesting flask through a cork. In denarcotizing opium, or morphia, these arrangements are very appropriate and economical.

Decoction is the solvent action of fluids at their boiling temperature, and is continued for a longer or shorter time as the case may demand. The heat is constant for each liquid, but is varied by the quantity of matter dissolved, and its nature, when the process is conducted in open vessels. When the boiling takes place under pressure, as in Papin's digester, or that of Chevreul, the temperature rises with the pressure. By taking advantage of this fact, the solvent power of water may be greatly increased, by subjecting substances to its action in close vessels under strong pressure. The gelatin of bones is most effectually extracted by this method. Chevreul's digester is a close cylindrical boiler, with a safety valve in the cover, which is pressed on by a spiral steel spring, that is capable of resisting a specified pressure, and when the force of the steam overcomes this resistance, it raises the valve and escapes. The spring is surrounded by a metallic chamber, from which a tube extends to a condensing apparatus.

The term *decoction* is rarely applied to any but aqueous solutions of vegetable or animal matter, obtained by boiling in water. Owing to the injurious effect exercised on many organic principles by exposing them to the combined action of heat and air, in the process of decoction, this method of solution is not as much esteemed as formerly, when organic chemistry was little understood. It is applicable when the substances sought to be extracted, are only soluble at the temperature of ebullition, as starch, some forms of mucilage, inulin, lichenin, &c., or where the fixed ingredients only of a compound are desired, to the exclusion of the volatile. It is a quick method of extraction, and may be resorted to in many instances where time is an object.

The only method remaining to be described is

The Displacement Process.—This was introduced into pharmaceuti-

eal operations about the year 1833, by the MM. Boullay of Paris, who derived their idea from the filter-press of Count Real, to be noticed hereafter. They assumed as the basis of their process the following theory. When a vegetable powder (placed in a cylindrical vessel with a porous diaphragm below) is treated from above with a liquid capable of dissolving a portion of its substance, that portion of the liquid first in contact, in passing downward, exercises its solvent power on the successive strata of the powder, until it becomes saturated, and is pushed down by the combined force of its own gravity and that of the column of fluid above it, minus the capillary force with which the powder tends to retain it. If the quantity of liquid added is not more than sufficient to satisfy the capillarity of the powder, no solution will pass out below, but by carefully adding more menstruum above, it displaces that absorbed, without mixing with it, and takes its place, to be in turn displaced by a further addition. This process has been introduced into the French Codex, and the United States and Edinburgh Pharmacopœias, in many of their processes, and its merits will be discussed in the application of the methods of extraction, to the preparation of extracts, tinctures, and syrups.—W. P.]

ON THE PREPARATION OF SOLUTIONS FOR EXTRACTS AND SYRUPS,
AND ON TINCTURES, WINES, VINEGARS, SYRUPS, ETC.

The preparation of extracts has occupied much of the attention of practical pharmacutists, and many propositions have, from time to time, been made, with the view of improving the process.

Extracts are frequently distinguished as *aqueous*, *alcoholic*, or *etheral*, according as one or other of the liquids indicated by these names has been used in their preparation; for not only the character of the extract, but the process also, depends upon the nature of the liquid used for extraction.

Improvements in the preparation of extracts must have reference either to the quality of the products, or to the economy of the process; and a correct knowledge of all that relates to these points is essential in determining which is the best of the many methods of proceeding which have been suggested.

[That part of their preparation which is effected by *evaporation* will be treated of more extendedly in the following chapter, whilst the methods of obtaining solutions for them will be here explained.—W. P.]

Solutions for Aqueous Extracts.—Berzelius, in his work on chemistry, has entered very fully into theoretical questions relating to the nature and preparation of extracts. He has shown that they undergo

important changes, and ultimately are completely spoiled, if long exposed to the action of heat, and especially a high temperature. Great care, therefore, ought to be taken, to avoid this source of deterioration.

There are three ways of preparing aqueous extracts, or rather, of making the solutions from which they are prepared:—1st, By boiling the solid ingredients with water; 2dly, By digesting them in boiling water; and, 3dly, By macerating them in cold water.

Extraction by boiling, can only be applied with advantage to hard woods, roots, and barks, such as guaiacum-wood, quassia, Peruvian bark, cascarilla bark, &c., which are with difficulty exhausted of their soluble parts. The substance to be operated upon is first to be cut or sliced, and then boiled with just enough water to cover it, and admit of its being well stirred with a spatula. It is better to avoid active ebullition, and induce only a gentle simmering, which should be continued for a quarter of an hour or twenty minutes. [There is an advantage gained in operating with considerable quantities of ingredients, by permitting them to macerate in cold water for 10 or 12 hours before raising the temperature to ebullition, so that the tissues may be thoroughly impregnated and swollen.—W. P.] The decoction is then poured into a strainer and allowed to drain; and the solid ingredients are twice more treated in the same way with fresh portions of water. These several decoctions are mixed together, allowed to settle, and then the clear liquor evaporated over the water-bath.

It should be observed, however, that, in making extract of Peruvian bark, the sediment which forms in the decoction as it cools is not to be separated and rejected.

In evaporating the liquor, a small quantity only should be introduced into the pan at a time; and when this has been evaporated, with the constant use of the stirrer, to the consistence of syrup, it should be taken out and the process repeated on another portion, until the whole has been thus reduced. Finally, these syrupy liquors, being united, are to be carefully evaporated to the consistence of an extract.

Formerly all aqueous extracts were directed to be made from decoctions of the solid ingredients. In process of time, however, it was ascertained, by experiment, that in most cases it was more advantageous to effect the extraction by means of infusion than by decoction. Thus, for instance, well-authenticated experiments have shown that

16 oz.	Rad. Patientiæ	gave, by decoction	3ij 3vj	Extract.
"	"	" by infusion	3iij	"
"	Rad. Gentianæ	" by 12 hours' cold maceration	3v 3ij 3ij	"
"	"	" by 12 hours' hot infusion	3v 3j	"
"	"	" by 15 minutes decoction	3iv 3vj 3ij	"

The extract obtained by infusion, and especially that by cold maceration, was more bright, clear, smooth, bitter, and odorous than that obtained by decoction.

16 oz. Rad. Consolidæ, gathered in March,	}	gave by infusion	℥ij ℥vij gr. 1,	Extract.
“ “			℥iij ℥iij gr. xxxvij	“
“ Rad. Rhei		“ by infusion	℥v. ℥vj	{ Clear extract, soluble in water.
“ “		“ by decoction	℥v	{ Turbid, slimy, extract, partly insoluble.

On the other hand,

16. oz. Cort. Cinchonæ	gave by decoction		℥iv gr. lxxxvij	Extract.
“ “	“ by infusion		℥iij gr. lxvij	“

Besides, the extract of bark obtained by decoction is much richer in alkaloids, and is of a different character from that obtained by maceration or infusion. Guaiacum-wood also yields more extract by boiling than by infusing, and the extract so obtained has a more balsamic odour.

16 oz. Rad. Rhataniæ gave, by decoction, ℥iij ℥vj gr. xxij extract, which consisted of—

℥xiij	gr. viij	soluble matter.
℥xviij	gr. xiv	insoluble matter.

16 oz. Rad. Rhataniæ gave, by infusion, ℥iij ℥iv gr. iij extract, which consisted of—

℥xviij	gr. viij	soluble matter.
℥ix	gr. 1	insoluble matter.

Thus, in case of rhatany, although more extract was obtained by decoction than by infusion, yet that obtained by the latter process contained the largest quantity of soluble matter.

The French Codex of 1839 contains a formula for extract of rhatany made with alcohol; but the extract thus made contains a very large quantity of insoluble matter. A quantity of the root that yielded 70 parts of aqueous extract, gave 120 parts of extract when treated with alcohol; but of this latter only 51 parts were soluble in water.

It appears, then, from these experiments, that in most cases the process by infusion yields extracts better in quality, and greater in quantity, than those obtained by decoction.

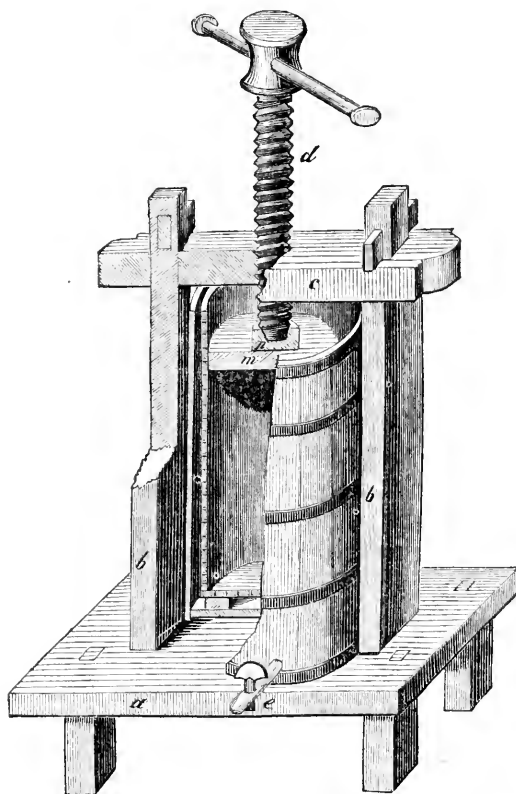
It remains to be considered what is the best method of proceeding in the preparation of extracts by infusion.

In order to use the smallest possible quantity of the extracting me-

dium, it is desirable to effect a rapid removal of the liquid as it becomes charged with the soluble matter of the substances operated upon; and there are three ways in which this is effected:—1st, By the press; 2dly, By displacement with high pressure; and, 3dly, By displacement with low pressure.

First, with regard to *the press*. The substances after having been infused are usually put into bags or wrapped in cloth, and put into one of the laboratory presses. This operation is very troublesome where there are large quantities of materials to be operated upon; and, as repeated additions of boiling water are required, this makes the substance to be pressed so hot, that much inconvenience is expe-

Fig. 256.



MOHR'S PRESS FOR EXTRACTIONS.

rienced in handling it. On this account, a particular press for extracts has been introduced, and I have already described and sketched

one of these in the "Annals of Pharmacy," vol. xxxi. page 303. Fig. 256 gives a correct representation of it.

In the stout oaken top (*a*) of a low table or stool, two square holes are cut, to receive the ends of the upright pieces of wood *b, b*, which pass through to be fastened below by wedges. A cross-beam (*c*) is fixed at the top, as shown in the drawing, and in this a female screw is cut, beneath which the press-tub stands. This press-tub is double, the inner one being perforated with holes. It is also furnished with a stop-cock (*e*). The substance to be operated upon being put into this tub, the water, either hot or cold, is poured over it; the press-block (*n*) is then placed on the top, and the ingredients are thus allowed to stand during the specified time, at the expiration of which the liquor is allowed to run off through the stop-cock, and pressure applied by means of the screw. This method of proceeding has been found to answer well. The liquor thus obtained is to be evaporated as already described.

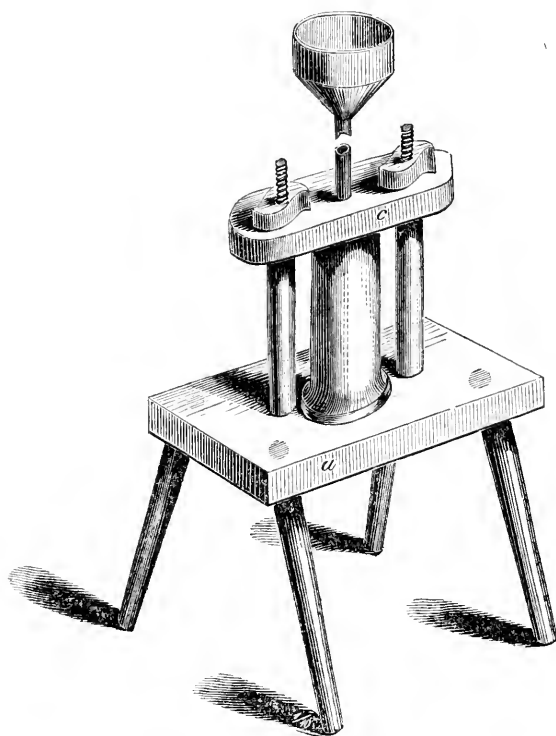
The Displacement Process.—The removal of a saturated solution from the solid ingredients which have been acted upon, by means of a superincumbent column of the uncharged solvent, was a fruitful idea, which caused much stir among pharmacutists, and has been productive of benefit to the pharmaceutic art.

When Count Real invented the press which has been named after him, the idea of effecting a more complete penetration of the vegetable fibres, and extraction of the soluble parts, than had previously been attained, appears to have prevailed in his mind, over that of merely displacing the solution when formed. This he proposed effecting by the pressure exercised by a column of water, increased by elongation to the extent required. In practice, however, it has been found that but little advantage was gained by the accumulated pressure acquired in Real's press; and successive attempts at simplification have resulted in the reduction of the gigantic forms and expensive construction of the original apparatus, with all its philosophic glory, to the dimensions of a sugar-loaf mould, or small tin cylinder.

The Press of Count Real.—Real's press consists of a metallic cylinder, in which the substance to be acted on is placed on a perforated disc. It has a cover which may be fixed on with a water-tight joint, and to the cover is attached a perpendicular tube, usually eight or ten feet high. In connecting these parts together, it has been found difficult to prevent leakage at the joints, especially when the tube is carried, as it sometimes has been, to the height of two or three stories of the building; and this has constituted one of the

practical objections to the use of the apparatus. In addition to this, the method generally adopted, of fastening the cover to the cylinder by means of screws, was found to be troublesome, as much time was occupied in fixing and unfixing it, and some of the screws were frequently lost. To obviate these objections, I have proposed a modification in the construction of the press, which is represented in fig. 257. Upon a stout table (*a*) two upright bars are fixed, the upper ends terminating in screws. These are connected by a cross-bar, *c*, which is fixed on by two nuts, such as the bookbinders have to their presses. In the centre of the cross-bar a female screw is cut, through

Fig. 257.



COUNT REAL'S PRESS, MODIFIED BY MOHR.

which the vertical pipe is to pass. There is also a hole in the centre of the table, through which the lower end of the cylinder, which has a stop-cock attached to it, passes, as shown in fig. 258. The top of the cylinder fits on with a collar, and a leather or pasteboard washer,

and these are closely compressed by the cross-bar, which is screwed tightly down by the nuts. The whole apparatus is thus rendered water-tight, and at the same time firmly fixed to its stand by means of the two nuts at the top.

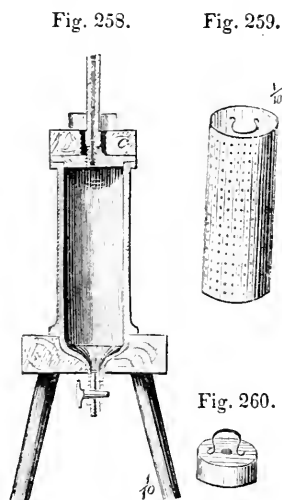
The perpendicular tube is screwed into the top through the hole in the cross-bar. The tube should not be less than seven lines in diameter.

The substances to be acted upon are placed in the cylinder, over the perforated strainer, in a dry or moist state, with certain precautions which will be subsequently stated; and the cover being fitted on, and the pressure-pipe fixed in its place, water is poured in through the funnel at the top, so that the ingredients in the cylinder shall be exposed to the pressure of a column of water. After standing for some hours, the liquor is slowly drawn off through the stop-cock at the bottom, while fresh water is added from above.

The principal objection to this apparatus is that the liquid passes too rapidly through the solid ingredients, in consequence of the pressure exercised by the column of liquid in the tube.

With a few additions, the apparatus above described may be rendered applicable for use as a mechanical press. For this purpose, a cylindrical strainer (fig. 259) must be made to fit into the cylinder of the press, and to stand on the perforated disc at the bottom. The materials are placed inside this, and a small press-block (fig. 260) put over them. The cover of the press and the vertical pipe are dispensed with, and, in place of the latter, a screw with a lever-handle at the upper end is passed through the hole in the cross-bar, which, as already stated, has a female screw cut in it, and this screw, acting on the press-block, effects the required pressure.

This application of the apparatus is very convenient in operating with spirit, as it admits of the extraction and the expression being effected in the same vessel, and thus the loss from evaporation and otherwise, that would occur in transferring the materials to another vessel, is avoided.



REAL'S PRESS, MODIFIED BY MOHR.

The objections which attach to the use of Real's press, have led to the adoption of a more simple method of effecting displacement, in which high pressure is avoided. Indeed, the process of displacement by low pressure may be said to have entirely superseded the other. The Real's press may be reduced to a low pressure displacement apparatus, as a slipper would be made out of an old boot, by removing all the upper portions.

The outer cylinder of the Real's press, placed on a suitable stand, is all that is required for a displacement apparatus.

The method of manipulating with this apparatus, so as to obtain satisfactory results, is not, however, so simple and easy as might be imagined; and the French pharmacutists have accordingly been occupied for years in classifying the different vegetable substances according to the treatment they severally require in submitting them to this process.

The process of displacement consists in pouring the liquid to be used over the solid ingredients, previously reduced to a state of division, and confined in a cylinder of greater length than diameter, and thus causing the liquid to pass through many layers of the solid body, until it becomes charged with the soluble matter, which it extracts and carries away with it.

The advantage of this process is said to consist in its effecting the exhaustion of the solid substances acted upon, of their soluble matter, with a smaller quantity of liquid than would be required under other circumstances. This is said to be accomplished in consequence of each particle of liquid coming successively in contact with a great number of particles of solid matter, while at the same time the latter particles are also successively acted upon by a great number of particles of the liquid.

If, as is assumed in the above theory, there were no obstacle to the equal penetration, in all parts, of the mass of solid matter, and of the separate particles of which it is composed, by the liquid, and, further, if there were no disposition in the different parts of the liquid, to intermingle with each other, the process would, indeed, accomplish all that could be desired. In practice, however, such satisfactory results are but rarely obtained. It is found that the fluid does not pass with the same facility through the pieces of solid matter as it does through the interstices between these pieces; that it frequently flows more freely through one part of the mass than another, in consequence of unequal packing of the materials, or from some other cause; and,

further, that, however well the materials may have been packed in the first instance, as the solvent extracts the soluble parts, the remaining solid matter occupies less space; and the mass, shrinking from this cause, forms a number of channels through which the fluid flows without further effect. Yet, notwithstanding these disadvantages, there are some cases in which the process of displacement is found to be available with much advantage.

In the application of this process, an essential condition of success is the reduction of the solid substances to the proper state of division. The opinion which has been formed by many persons, that certain substances of a mucilaginous nature are impenetrable, and cannot be exhausted by displacement, has probably been formed in consequence of a want of proper attention to the above condition. There are, I believe, few substances that do not admit of being treated by this process, if all the necessary conditions be observed.

Leaves, herbs, or the tops of plants, when properly dried and made friable, may be rubbed through a sieve of about 10 meshes to the square inch, or they may be cut up and then passed through the sieve. Barks, roots, and all kinds of wood, are properly cut up, or bruised in a mortar or mill, and finally sifted, the coarse powder only being used, while the fine is set aside for some other purpose.

Mucilaginous substances should be less finely comminuted than those of a more woody nature.

It would be difficult to describe the degree of division necessary for each separate substance; this must be left to the judgment and experience of the operator. It would be equally difficult to decide how much of the solid substance ought to be put into the cylinder at once, as this depends on the nature of the substance.

There are two methods of proceeding in the treatment of vegetable powders by displacement; one consists in packing the dry substance in the apparatus, and pouring the liquid over it until it begins to run out at the bottom, when the moistened mass is allowed to stand for some time with the stop-cock shut off before the displacement is commenced; the other consists in moistening the powder in a separate vessel, allowing it to stand for some time, and then packing it in the cylinder of the apparatus.

The former of these methods offers no advantage over the other, while it is frequently found that the powder does not become completely moistened when thus treated, and hence that one of the principal objects of maceration is frustrated. It also occurs, frequently, that, when the

powder is moistened in the cylinder of the apparatus, it swells on the addition of the liquid, and thus becomes so tightly packed as to resist the further passage of the liquid. This inconvenience is principally experienced when water is used as the extracting agent.

A dry sponge imbibes water but sluggishly; while, on the other hand, a moistened and expressed one absorbs it greedily: so, in like manner, a dry powder offers some resistance to the entrance of water; while in a moistened powder, the absorption is promoted through the influence of capillary attraction. The resistance offered by the dry powder arises partly from the formation of an impenetrable coating on the surface, by the swelling of the first particles that are wetted, and partly by the pressure of air between the particles of the powder, which has not sufficient means of escape.

[Though as a general rule, with aqueous liquids, it is better to resort to previous maceration in a separate vessel with a sufficient quantity of water to thoroughly saturate the substance treated, yet there are instances where a decided advantage arises from immediate displacement of the dry or slightly moistened powder. In the preparation of solutions for extracts, where the substances do not swell too much, or are not mucilaginous, as rhatany root, the first portion of liquid that passes is highly charged with the most valuable part of the soluble matter. This should always be evaporated separately from the more dilute portions, and admixed with them at the close of the process.—W. P.]

The best method of effecting the moistening of the dry substances is that which was originally suggested by Count Real, and which consists in adding to the powder half its volume of water, allowing the mixture to stand for some hours, then packing it more or less closely in the cylinder of the apparatus, covering it with a piece of linen or with paper pierced with holes, and finally pouring water over it. Should the liquor run off too rapidly, the powder should be pressed a little closer in the cylinder, or the escape of the liquid be regulated by means of the stop-cock.

Soubeyran has made a classification of substances, according to the pressure they require to be submitted to when treated with water by displacement, which is as follows:

To be strongly pressed:—

Chamomile flowers,
Arnica flowers,

Hops,
Quassia wood.

To be pretty strongly pressed:—

Bistort root,	Liquorice,
Cahinca root,	Peruvian bark,
China root,	Pomegranate bark,
Colchicum cormus,	Rhatany root,
Calumba root,	Sarsaparilla,
Dulcamara,	Willow bark,
Ipecacuanha,	Valerian root.

To be moderately pressed:—

Aconite plant,	Rue,
Anemone,	Savine,
Belladonna,	Stramonium,
Buckbean,	Soapwort,
Hemlock,	Veronica.

To be slightly pressed:—

Borage,	Nut-galls,
Great Burdock,	Parsley root,
Gentian root,	Senega root,
Heartsease flowers,	

Not to be pressed at all:—

Red roses,	Saffron,
Rhubarb,	Squill.

The displacement process cannot be advantageously applied to poppy capsules, and there are difficulties in the way of applying it to gentian and rhubarb. The last-named, if treated at all by this process, should be reduced to very coarse powder and moistened with an equal weight of water, before commencing the displacement. The best method of treating senna is, to bruise it slightly, then pack it in the apparatus and add four times its weight of water, and after allow it to macerate for twelve hours, to proceed with the displacement.

[Rhubarb, senna, and poppy capsules, are too mucilaginous for successful treatment with water by displacement; but if a menstruum, consisting of one part of alcohol and four of water, be employed, they can be displaced readily. Gentian should be finely ground, mixed with its weight of sand, saturated with water, and after the particles are thoroughly swollen by maceration, the whole should be put in the displacer, shaken down, and the process proceeded with.—W. P.]

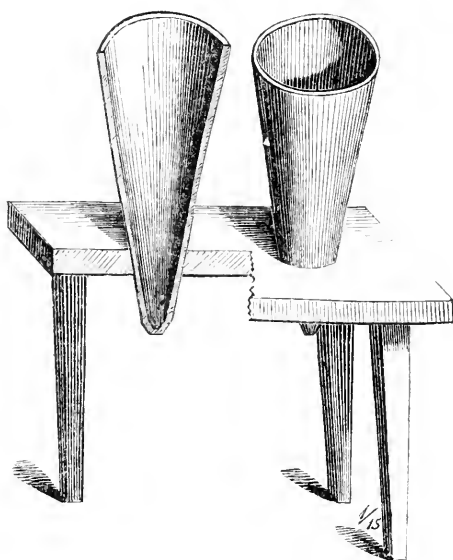
Complicated or expensive forms of apparatus are not required for conducting this process, and this certainly constitutes a recommendation to it. In the absence of a metallic cylinder, a sugar-loaf mould, such as is represented in fig. 261, may be conveniently used. These moulds are conical earthenware vessels, with a small opening at the apex. They are used for crystallizing the loaves of sugar, and may be obtained from the sugar-refiners where they are constantly in use, from the stone-ware manufacturers who make them, or from any common potter who would make them to order. As obtained from the last-named source, however, they would not be so strong as those made for the sugar-refiners. Two or more of these vessels are fixed

in a table, as shown in fig. 261. In using them, the liquor obtained by treating the solid ingredients in one mould is added to a fresh portion of the same ingredients in the next mould, and so on until the liquor becomes highly impregnated. In this way, when there are large quantities of materials to be operated upon, very strong solutions are obtained, which, in proportion to their concentration, require less evaporation in reducing them to the condition of extracts, and thus one of the most fruitful sources of deterioration in these preparations is avoided.

[An apparatus has been patented by C. A. Smith, of Cincinnati, in using which the processes of infusion and displacement are combined. It possesses some decided advantages in the preparation of solutions for certain aqueous extracts, when an abundant supply of steam is at command.

This apparatus, fig. 262, consists of a displacement cylinder, A, with a diaphragm at its base; B is a refrigerator surrounding the displacer, and which is kept supplied with cold water by the pipe and funnel G; C is a boiler in which the steam is generated for small ope-

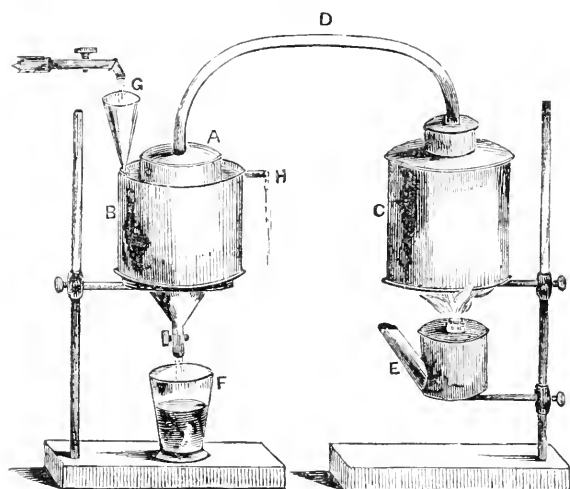
Fig. 261.



DISPLACEMENT APPARATUS.

rations ; D, a tinned leaden tube, connecting the boiler with the displacer ; and E the source of heat.

Fig. 262.



SMITH'S DISPLACEMENT APPARATUS.

In using this displacement machine, the ingredients are placed in the cylinder unmoistened, their state of division being regulated by the same rules as are observed in ordinary displacement ; the top is then luted on with linseed-meal mucilage, spread on a strip of cloth, and a current of steam passed in until it commences to escape freely below, by which time the ingredients will be saturated and swollen. The refrigerator is now filled with water, and the process proceeded with until the fluid that passes is but slightly charged with soluble matter. The displacer should be of smaller proportional diameter than is seen in the figure, or there should be an inner cylinder filled with cold water, because the central column of the ingredients is apt to be less acted upon than the portions adjacent to the condensing surface. Very concentrated solutions may be obtained by this instrument. The first runnings from *uva ursi* leaves yielded 25 per cent. of extract by evaporation. Senna is extracted readily by it, and indeed all the mucilaginous substances not proper for cold displacement. It does not apply to rhatany, or any substance containing matter soluble in boiling water, which it is desirable to avoid, as starch and apothegm.

Various other suggestions have been made with a view to facilitating the extraction of substances by watery displacement. Payen proposed

that air should be forced into the space above the ingredients, the top of the displacer fitting air-tight; and Zenneck modified Count Real's idea, so as to press on a short column of liquid above the ingredients with a piston, operated on by a loaded lever; but the idea of Beral is perhaps the most eligible of these suggestions. Beral's displacer is constructed precisely on the principle of the vacuum filter, fig. 195, the displacer fitting air-tight into a reservoir beneath, from which the air is exhausted by a small exhausting pump attached. Its action is obvious: the surface of the fluid in the displacer is pressed on by the atmosphere, in proportion to the state of exhaustion of the reservoir. Geiger strongly recommends this apparatus, and Soubeiran views it more favourably than either of the other suggestions. Their expensiveness, however, more than counterbalances the advantages that are derivable from their employment. Every pharmacist should gain a knowledge, by experience, of the relations of each important drug to the several menstrua, in the process of displacement, and he will then find more uniform success, than by depending solely on suggestions derived from authorities.—W. P.]

Let us now consider the question, which of the two processes described, that of expression, or that of displacement, affords the most satisfactory results?

According to my view and experience, the advantage is on the side of the process of expression.

The process of displacement offers advantages only when continued uninterruptedly with large quantities of the same materials, so that solutions which are comparatively weak may be rendered stronger by using them to act on fresh portions of unexhausted materials. In pharmaceutical operations this is rarely possible, as the quantities operated upon are generally small. The influence produced by the extent of the operations will afford an explanation of the difference in the results which have been obtained in the application of this process in large and in small laboratories. The process of expression is not subject to this defect, the results being alike with small as with large quantities.

In the displacement process the solutions first obtained are the most concentrated, but they soon decrease in strength, and continue for some time to get weaker, although still sufficiently strong to prevent their being rejected; and if there be no more substance to be acted upon by these weak solutions, there is no alternative but to concentrate them by evaporation. In the process of expression, the liquor obtained is of the same degree of concentration throughout the opera-

tion. It is true that the marc still retains a small quantity of liquor similar to that which has been expressed, but this may in a great measure be removed by the addition of a little more water, and a second expression. Substances which are with much difficulty treated by displacement, such as rhubarb, gentian, nutgalls, &c., present no difficulties in the process of expression; indeed, this is frequently resorted to as the readiest means of finishing the operation after beginning it by the other. Expression is advantageous, in many cases, from its tending to burst the fibres, which in their unbroken state retain portions of soluble matter, or of solution, which is not otherwise easily removed.

Moreover, with regard to the time required for conducting either process, the press again has the advantage. By the application of heat, the extraction may be accelerated, and the expression then effected as soon as deemed expedient. In the case of ordinary displacement, no further heat can be applied; and with substances of a mucilaginous nature the percolation is so slow, that the ingredients frequently become mouldy and spoil before the process is finished. Sometimes the percolation stops altogether, and in these cases there is no other remedy than resorting to the press.

Finally, I conclude, from these several views of the question, that the process of expression, with properly constructed apparatus, is preferable to that of displacement.

ALCOHOLIC AND ETHEREAL SOLUTIONS FOR EXTRACTS AND TINCTURES.—Alcohol and ether swell out the fibres of plants to a much less degree than water does, and therefore the process of displacement may generally be conducted with these liquids without any difficulty. Indeed, it is more frequently found that the menstruum flows too rapidly, by the formation of channels. Vegetable powders should therefore be reduced to a finer state of division, and compressed more closely in the cylinder, when intended to be acted on by alcohol or ether, than would be the case when water is used.

In the preparation of solutions for aqueous extracts, it is an object of some importance to effect the exhaustion with as small a quantity of liquid as possible, partly with the view of preventing decomposition resulting from a protracted evaporation, and partly from motives of economy in the use of fuel. But, when alcohol or ether is used, the only consideration will be the economy of the menstruum, on account of its expense.

If the relative merits of the two processes, already adverted to, namely, those of expression and displacement, be compared, in refer-

ence to the preparation of alcoholic and ethereal solutions, the advantage in economy will be found to be on the side of expression.

The common mode of proceeding is, to digest the substance with spirit in a retort or alembic, and then to place the mixture, when completely cold, on a straining-cloth, and, after allowing as much of the liquor as will do so spontaneously to run through, to press the remainder strongly with the hands.

This very simple process has the disadvantage of involving a rather considerable loss of spirit, and a still greater loss if the menstruum be ether. In the latter case the loss may amount to nearly three-fourths the quantity used, if the process be on the small scale.

It is a great improvement, in conducting this process, to effect the extraction and expression in the same vessel, in the manner already described under the head of "Real's Press," and illustrated by figs. 257, 258, 259, and 260. The access of air, which occasions so serious a loss of spirit or ether, is thus avoided.

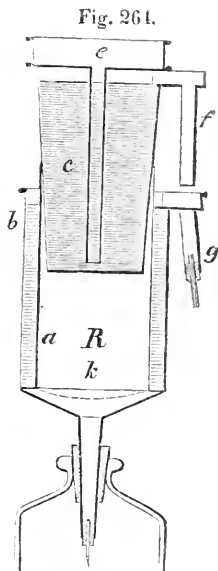
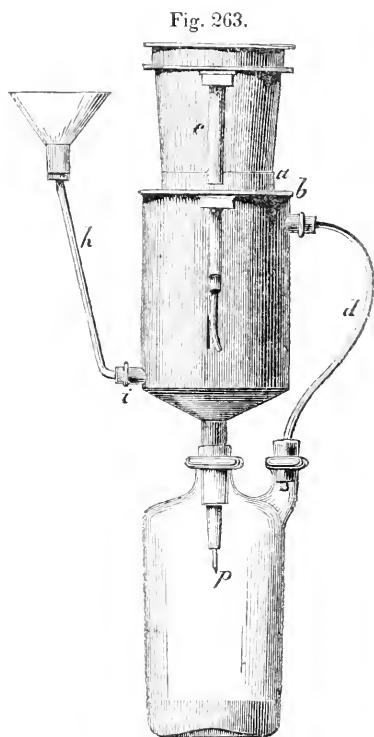
If the substance to be acted upon be in the form of powder, it should be placed in the cylinder of the press in a bag of loose texture. The fluid, as it runs through, should not be collected in an open vessel, such as a dish, but should flow at once into a bottle.

Notwithstanding these precautions, however, considerable loss is sustained in preparing ethereal extracts, in consequence of the great volatility of this liquid; and when only small quantities are operated upon, the loss from spontaneous evaporation and absorption by the bag is so great, as to render it scarcely worth the trouble to recover the remainder by distillation.

I have recently constructed an apparatus, consisting of a perfectly close vessel, for effecting extraction with small quantities of ether, and for recovering the ether by distillation.

Figs. 263, 264, and 265 represent this apparatus, which consists of a two-necked Woulf's bottle, (fig. 263, *p*.) into the central mouth of which the metallic vessel (*R*, fig. 264) is fitted by means of a cork.

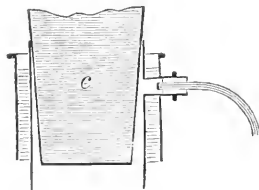
The vessel *R* consists of a metallic cylinder (*a*, figs. 263 and 264), having a perforated strainer (*k*) near the bottom, and terminating with a funnel-neck, to admit of its being fitted into the Woulf's bottle. This cylinder is surrounded by a second cylinder (*b*), the space between them being intended to contain either hot or cold water. Into the top of the inner cylinder (*a*) a slightly conical vessel (*c*) is made to fit airtight, as shown in the drawing. This vessel (*c*) is intended to be used as a condensing apparatus, and for this purpose it is filled with cold water. From the second or lateral opening of the Woulf's bottle, a



APPARATUS FOR MAKING ETHEREAL TINCTURES.

glass or tin tube (*d*) is carried to the upper part of the cylinder *a*, where it is inserted, as shown in fig. 265. The cold water in the vessel *c* is renewed through the pipe *e*, which conducts it to the bottom, while the warm water runs off from the top through the pipe *f*. Hot or cold water is renewed to the space between the two cylinders (*R*), by the tube-funnel *h*, and the water from this space overflows into *g*, and is carried off together with that from *f*.

Fig. 265.



The tube *h* is inserted through a perforated cork at *i*, so that, by turning the tube downwards, the water from the space between the cylinders can be thus allowed to run off.

The method of operating with this apparatus will now be easily understood. The substance, in coarse powder, is placed upon the perforated strainer in the space marked *R*, (fig. 264,) over a piece of

flannel, cut to the size of the strainer. Ether is now poured over the substance to be operated upon, and allowed to percolate through it and run into the Woulf's bottle. The tube *d* is fixed in its place, and cold water is introduced into the space between the cylinders *a* and *b*, and into the vessel *c*. The bottle is now immersed in hot water, so as to cause the ether which has run into it to boil; and the vapour passing through the tube *d* into the upper part of the vessel *R*, is condensed there by the action of the surrounding cold water, and again passes in the liquid state through the substance to be exhausted. This circulation of the ether may be continued, without loss, until the solid substance is completely exhausted, which will be indicated by the ether dropping into the bottle colourless.

The extraction is in this way effected very rapidly. The following results were obtained from the treatment of eight ounces of worm-seed with ether. The worm-seed, in coarse powder, was put into the cylinder at *R*, and eight ounces of ether poured over it. The ether was nearly all absorbed by the powder, and scarcely anything passed into the bottle below: four ounces more of ether was therefore added, when a strongly-coloured solution passed. Heat was now applied, so as to boil and evaporate the ether, and in a few minutes afterwards a deep green liquor began to drop from the cylinder. As the heat was continued and increased, the returning liquor increased in quantity, so as to run in a stream, until the perfect exhaustion of the worm-seed was indicated by the return of colourless ether. The apparatus was now taken out of the warm water, and allowed to cool. The cold water was in the next place removed from the space between the cylinders *a* and *b*, by turning down the tube *h*, and the water was also emptied out of the condenser (*c*). The tube *d* was removed, the neck of the bottle into which this had been inserted being at the same time closed with a cork; while from the opening into the cylinder, where the other end of the tube *d* had been inserted, a tube was fixed connecting it with a Liebig's condenser. Hot water was now poured through the funnel and tube *h* into the space between the cylinders, which, heating and vaporising the ether with which the powder was saturated, caused it to distil over through the condenser. This being completed, the vessel *R* and its appendages was removed from the Woulf's bottle, and a tube made to connect the mouth of the bottle with the Liebig's condenser; when hot water being again applied to the bottle, the ether distilled off, until a syrupy liquor was left, which was finally evaporated to the consistence of butter in a porcelain dish.

The eight ounces of worm-seed was thus completely exhausted in an hour and a half, with twelve ounces of ether, of which nine ounces was again recovered by distillation, and the resulting extract weighed ten drachms. With greater care in the condensation of the ether, I think another ounce might have been recovered.

This apparatus may also be applied in the process of extraction with spirit; but in this case it is necessary to apply more heat, by using a solution of chloride of calcium or a sand-bath.

If the principle of this apparatus were carried out on the large scale, and a metallic vessel employed instead of the glass bottle, the exhaustion of sabadilla-seeds, and even of bark, for the preparation of the alkaloids, might, no doubt, be accomplished with the smallest possible loss of alcohol.

In making *Tinctures* the principal objects to be aimed at are—

1. To effect the solution of those parts of the solid ingredients used which are intended to be administered.
2. To obtain transparent solutions, which, when made at different periods, shall not vary in strength or composition.
3. To effect the above objects with the smallest possible loss of ingredients, or expenditure of time.

Three different processes have been adopted for the preparation of tinctures :—

1. The process by maceration as directed in the London Pharmacopœia.
2. The process by maceration as modified by Dr. Burton.
3. The process by percolation or displacement.

Preparation of Tinctures by Maceration as directed in the London Pharmacopœia.—This is a very simple process: it consists in putting the solid and liquid ingredients, together, into a stoppered glass-vessel; allowing them to stand, generally for fourteen days, frequently shaking them during this time; and, lastly, straining off the solution. This is the method which, formerly, was always adopted for the preparation of tinctures. It has been thought, however, to be subject to some objections, and hence the introduction of other processes. When dry solid ingredients, either animal or vegetable, are macerated in spirit or other similar menstrua, as is the case in this process, the liquid immediately in contact with the solid matter at the bottom of the macerating vessel forms a saturated solution, which, being more dense than the liquid above it, prevents the contact and solvent action of the latter. It is on this account that the vessel is directed to be frequently shaken during the maceration; but when large vessels are

employed, agitation is not easily effected, and, under any circumstances, the repetition of this very necessary part of the process is liable to be neglected.

Preparation of Tinctures by Maceration as modified by Dr. Burton.

—This process has been proposed with the view of obviating the objections which apply to the process of maceration as usually conducted. It differs from the preceding in the adoption of an arrangement for suspending the solid ingredients near the top of the liquid, instead of allowing them to subside to the bottom. This is effected, either by having a perforated diaphragm midway between the top and bottom of the macerating vessel, on which the ingredients are put, or by enclosing the ingredients in a bag and suspending this bag by a string.

The advantages of this method of conducting the process as compared with the other are, that there is no necessity for shaking the vessel, and that the exhaustion of the ingredients is effected in a shorter time. The process is automatic: when the spirit begins to act on the solid, a coloured tincture will be seen to gravitate through the colourless and lighter spirit by which it is surrounded, the latter, at the same time, ascending and coming into contact with the solid matter. A descending and ascending current is thus established throughout the fluid, and continues until no more soluble matter is extracted.

This process is founded on the same principle as Mr. Alsop's method of making infusions, and a vessel, somewhat similar in construction to the infusion-pot described at page 245, might be used for effecting the maceration in the way proposed. It would be necessary, however, to have means for preventing evaporation of the spirit during the process, and this with a cylindrical vessel, the mouth of which is not contracted, involves some difficulty, and constitutes probably the greatest impediment to the general adoption of the process.

In making tinctures by maceration, according to either of the foregoing processes, it is important to attend uniformly to the instructions given, with regard to the time during which the ingredients are allowed to macerate. It is, however, sometimes difficult strictly to observe these instructions, especially where small quantities only are made at a time.

The number of tinctures employed in medicine is so great, and their consumption necessarily so unequal, that scarcely a week will elapse without its being found necessary to commence the preparation of some of them. There will, generally, therefore, be several tinctures macerating at the same time, which have been commenced at

different periods, and it is difficult to recollect or attend to the precise time when the maceration in each case ought to terminate. The consequence of this is, that tinctures are often macerated for a much longer time than the Pharmacopœia directs. This is a common source of error in operating by this process, for the characters and properties of a tincture which has been allowed to remain for a long time in contact with the solid ingredients will often be found to differ considerably from what they would have been if the process had been terminated earlier.

Again: it often happens that the necessity for commencing the preparation of a tincture is only discovered when the stock on hand is nearly or entirely exhausted, and the tincture may perhaps be wanted for use before the maceration has continued for the proper length of time, so that there is a strong temptation to use it in its unfinished state. This is another evil resulting from the length of time occupied in the process of maceration. Moreover, when small quantities of tincture are made at a time, it is difficult to press the dregs completely, so as to avoid considerable loss of the product from this cause. Hence many persons allow the dregs to accumulate in the macerating vessel, making several fresh portions of tincture in contact with the dregs of previous preparations, until enough has accumulated to admit of their being efficiently pressed. This method of operating is subject, in an increased degree, to the objection which has already been urged against prolongation of the process of maceration beyond the specified time. Thus the process for the preparation of tinctures by maceration is subject to some practical objections or difficulties. These are frequently experienced; and it was at one time thought that an easy means of obviating them had been discovered in the adoption of the process next to be described.

Preparation of Tinctures by the process of Percolation or Displacement.—This process is of comparatively recent introduction as a means of preparing medicines, although it has long been employed in the arts. It is sometimes called *lixivation*, and under this designation it is especially applied to the solution of certain salts, as, for instance, in the preparation of soap-makers' ley. It is, of course, merely employed in those cases where only a part of the solid ingredients to which a liquid is added is soluble.

In making caustic leys for the soap-maker, it is important to recover all the alkali in solution from the mixture of lime and potash or soda, without using an undue quantity of water. This is done by allowing the solution first formed to run off from the solid residue, so

much only remaining as is absorbed by the mass of moist carbonate of lime. This latter portion of solution is next removed by pouring some water over the surface of the wet mass, and allowing the liquid to run off through an opening at the bottom of the vessel in which the process is conducted. Under these circumstances, the alkaline solution is displaced by the pressure of the column of water above it, and this displacement may be effected without any appreciable admixture of the two liquids, so that the whole of the alkaline solution is obtained without its being diluted to any sensible extent.

The same process is applied in a somewhat similar manner in brewing, with the view of obtaining as large a proportion as possible of saccharine matter from the grain in a concentrated state; and in this case the process is sometimes called *sparging*. In both the above instances water is used as the menstruum, and the process is usually conducted continuously with repeated quantities of fresh ingredients under circumstances which greatly favour its successful application. The results have proved satisfactory.

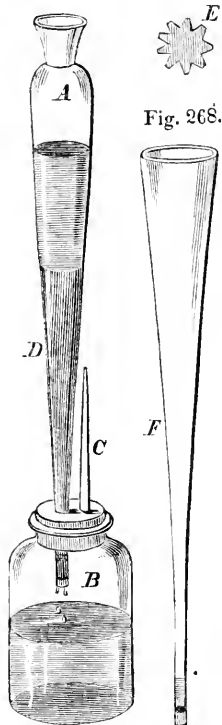
In making tinctures by this process spirit is used as the menstruum, and the circumstances under which the process is conducted are less favourable than in the other cases mentioned, to its complete success. The results, therefore, have proved but partially satisfactory. There are some cases, however, in which displacement may be advantageously applied in the preparation of tinctures; it is mentioned in the Edinburgh Pharmacopœia as one of the means which the pharmacist is allowed to adopt in making most of the tinctures for which formulæ are given in that work, and for some of them it is recommended as the best process.

Several forms of apparatus have been adopted by different operators for performing this process. Some of these have been already noticed at pages 253, 254, and 259. In its essential parts the apparatus always consists of a cylindrical or conical vessel into which the solid and liquid ingredients are put, and a receiver for collecting the product. Fig. 266 represents the most simple form of the apparatus adapted for the preparation of tinctures. A, is a glass adapter, which is selected of suitable size. The lower extremity of this is partially stopped with a cork cut as represented in fig. 267. A layer of coarsely pounded glass is put over the cork, and above this a layer of clean sand, thus forming a strainer for arresting the passage of the solid particles of the materials to be operated upon. The end of the adapter is fitted, by means of a perforated cork, into the mouth of a bottle. A glass tube, one end of which is drawn to a capillary

opening, is also fixed in the cork as shown at C, so as to allow the air to escape out of the bottle as the liquid drops in. The solid ingredients to be operated upon, previously reduced to powder, are placed

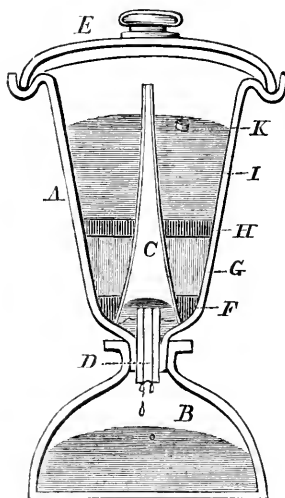
Fig. 266.

Fig. 267.



DISPLACEMENT APPARATUS.

Fig. 269.



GILBERTSON'S DISPLACEMENT APPARATUS.

in the vessel A, above the sand, as shown at D, and the spirit is poured over the surface of these, and allowed to percolate through. A piece of bladder may be tied over the mouth of the vessel at A, to prevent the evaporation of spirit, but a few pin-holes must be made in the bladder, to admit of the ingress of air as the liquid passes into the receiver below.

The neck of a broken retort, cut as represented by fig. 268, may be substituted for the adapter; in fact, any cylindrical or conical vessel of convenient size might be used, provided that a suitable strainer can be fixed to the lower extremity, and efficient means adopted for preventing the loss of spirit by evaporation.

But, of all the several kinds of apparatus which have been suggested,

I have found none so generally convenient and efficient as that represented at fig. 269. This form of apparatus was contrived by Mr. Gilbertson, of Ludgate Hill, by whom it is sold. It consists of a conical vessel (A), with a water-joint rim at the top, into which the cover E fits. A tube (D) is ground to fit into the opening in the bottom, and over the end of this tube is placed a conical tube (C), the lower end of which has several notches cut in it, so that the liquid can pass under it when placed as shown in the drawing. The lower extremity of the vessel A is ground to fit into the mouth of the receiver (B).

In using the apparatus, the cover (E) is removed, and some dry, clean sand is poured into the vessel A, so as to form a layer (F) at the bottom. Over this the solid ingredients to be operated upon (G) are carefully packed, and a layer of sand (H) is placed over these. The spirit (I) is then poured over the surface of the sand, care being taken not to disturb the ingredients below. The best method of guarding against the disturbance of the dry ingredients, on pouring the spirit in, is to place a flat cork (K) on the sand, and to direct the stream of liquid on to the cork, which will float on the surface of the liquid when introduced; the force of the current will be thus broken, and the operator enabled to pour in the whole quantity of spirit required, without affecting the position of the solid ingredients. The cover is then to be put on, and a little water poured into the groove, so as to render the joint air-tight. The spirit will percolate slowly through the different strata of dry ingredients until it reaches the bottom, then, passing under the tube C, it will ultimately drop down, through the tube D, into the receiver, while, at the same time, an equal volume of air passes up through the tubes to supply its place in the upper vessel, and equalise the pressure. Thus arranged, the apparatus is perfectly air-tight, so that no loss from evaporation can occur, however long the process may be in operation. The form and size of the apparatus, also, are such as to admit of the solid ingredients being properly packed in the vessel A, upon the skilful performance of which the success of the process principally depends. In most cases it is desirable to use these ingredients in fine powder, and, in some instances, they may be advantageously mixed with coarse sand, which, by separating the particles, will facilitate the percolation of the liquid. If the ingredients be properly packed, the spirit, when first added, will be slowly absorbed by the powder, and will descend equally on every side, forming a line round the circumference of the vessel, which will gradually pass downwards until the tincture begins to flow through the tube D. Some experience and judgment are re-

quired in regulating the degree of pressure to be applied in packing the powders, or, if necessary, mixing them with sand, so as to insure a regular and continued percolation; and, as differences in the nature of the substances operated upon, the degree of comminution to which they have been subjected, and the form and size of the apparatus employed, so far influence the results as to occasion the necessity for some modifications in the method of operating, no precise instructions can be given that would be applicable to all cases.

[Fig. 270 represents a displacer on the principle of Gilbertson's. A is an ordinary tin displacer, except that the rim *c* is soldered around the mouth, in such a manner as to form a water-joint when the rim of the cover, *d*, is placed in it. *a* is a perforated diaphragm; *e* a tin

Fig. 270.

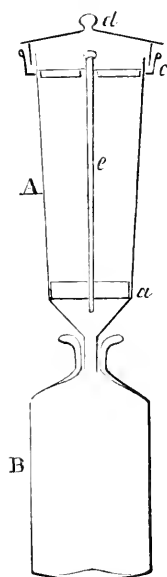
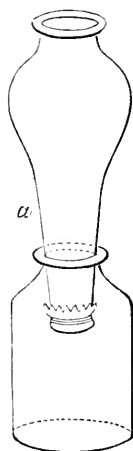
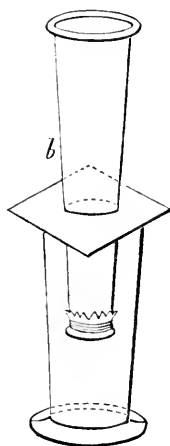
DISPLACER FOR
VOLATILE LIQUIDS.

Fig. 271.



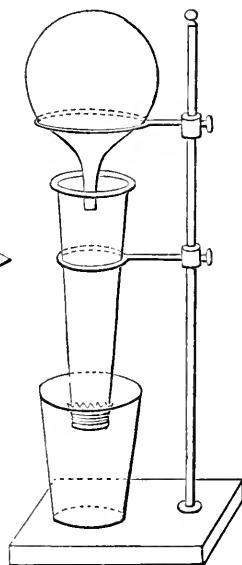
GLASS DISPLACER.

Fig. 272.



GLASS DISPLACER.

Fig. 273.

CONTINUOUS
DISPLACEMENT.

tube open below and above; this is soldered to the lower diaphragm, through which it passes, whilst the upper diaphragm slips over it loosely. In using this displacer, the ingredients are introduced around the tube to a suitable height, the upper diaphragm put in its place, the menstruum poured on, the joint half filled with water, and the lid inserted. The atmosphere of the bottle B, communicates with that of A, through the tube *e*.

Excellent displacers for small operations are made with ordinary glass lamp chimneys, figs. 271 and 272, by tying a piece of muslin, previously moistened, over their smaller ends, and inserting them in wide-mouthed bottles, as *a*, fig. 271, or through pieces of tin or eard, as *b*, fig. 272, in which cases they can be placed on any wide-mouthed vessel. One great advantage of these glass displacers is, that the operator can assure himself of the proper stratification of the powder, or moist mass.

When several operations are proceeding at the same time, and the attention of the operator is much occupied, it frequently happens that the process stops for want of a further addition of menstruum. In this case, the arrangement for continuous displacement, fig. 273, may be advantageously resorted to. A small mouthed bottle filled with the menstruum will answer instead of the flask. The action is obvious: as the liquid in the displacer descends below the mouth of the inverted flask, the fluid in the latter passes out, and preserves the level of that in the displacer.—W. P.]

The process answers remarkably well for extracting the whole of the soluble matter from ginger, Cayenne pepper, cantharides, ipecacuanha, and other substances, from which occasionally concentrated tinctures are required to be made. There is probably no case in which the result is more satisfactory than in the preparation of *Essence of Ginger*. The ginger should be used in fine powder; indeed, in all cases in which substances such as those above named are operated upon, I consider it essential to the complete success of the process that they should be in a state of minute division. The powder being introduced into the displacement apparatus, and carefully packed with a slight pressure, so that there shall be no open spaces or channels through which the liquid can pass more freely than through other parts, the layer of sand is placed over the surface of it, and, by means of the cork float, a portion of spirit, rather more than equal in weight to the ginger used, is introduced. The absorption of the spirit will immediately commence, and if the line indicating the division between the part of the powder which is wetted by the spirit and that which remains dry form a pretty uniform circle round the cylinder, and progress downward uninterruptedly as the absorption proceeds; and, further, if this descent of the spirit through the ginger take place at the rate of about an inch in five minutes, it may be inferred that the powder has been well packed, and equally compressed in all parts. The quantity of spirit mentioned will be just that which the ginger and the sand will be capable of absorbing, without any, or more than

a few drops, passing into the receiver. When the absorption is finished, the apparatus should be allowed to stand without further addition of spirit for an hour or two, so that complete penetration of the particles of ginger, and solution of all the soluble parts, by the spirit, may take place. At the conclusion of this maceration, the displacement of the tincture is to be effected, by carefully pouring another portion of spirit, equal to that previously absorbed by the solid ingredients, into the upper part of the cylinder, using the cork float as before, so as to prevent any disturbance of the moist ingredients below. The liquid, which was previously retained in contact with the particles of solid matter by the force of capillary attraction, is now forced downwards by the pressure of the column of liquid above; it will begin, therefore, to flow through the tube D, into the receiver B, and, if all the conditions mentioned have been properly observed, this displacement of the saturated tincture by the superincumbent spirit will take place without the occurrence of more than a very slight admixture of the two liquids. The progress of this part of the process will be indicated by a line showing where the two liquids join, the liquid above this line being nearly pure spirit, while that below it is a dark-coloured tincture. When this line has reached the bottom of the cylinder, the tincture formed by the solvent action of the first portion of spirit on the ginger will have been displaced, as completely as the process will admit. It will be found, however, that the displacement is not perfect, and this arises principally from the circumstance that the particles of which the powdered ginger is composed are porous. The spirit first added fills the pores of each particle, as well as the interstices between the different particles; but, as the former are smaller and more confined than the latter, the second portion of spirit, or displacing column, passes more freely through the interstices than through the minute pores of the particles; and, therefore, while the tincture filling the interstices is completely, that contained in the pores is but partially displaced. It will be observed, on close examination, during the process, that the line of demarcation between the two columns of liquid, to which allusion has already been made, becomes somewhat less defined and distinct as it approaches the bottom of the cylinder, a shading in the upper column being perceptible, which is occasioned by the diffusion and accumulation of the contents of the minute pores in the displacing liquid. Thus, a part of the tincture first formed will be mixed with the second portion of spirit added, or that used for the purpose of displacement, until the minutest pores have at length been emptied of their original contents. In order to recover the whole of

the soluble matter, therefore, it will be necessary to displace at least a part of the second portion of spirit; but the tincture thus procured will be much weaker than the preceding.

In operating in this way, nearly the whole of the active and soluble constituents of the ginger are obtained in solution in the first portion of tincture displaced, and, by continuing the process until a quantity of tincture rather less than double the weight of the ginger has passed into the receiver, the solid residue will be so completely exhausted as not to retain the slightest taste or smell.

But although a very concentrated solution is thus obtained, and the whole of the soluble matter is recovered, the process would not be an economical one if the spirit used for displacing the tincture were not recoverable. The displacement of this spirit by means of water is, therefore, the next step in the process. This is done by pouring water over the surface of the solid residue, in the same manner as the spirit was previously added. Pure spirit will in the first instance flow into the receiver as the column of water descends; but long before the whole of the spirit present has been thus recovered, it will be found to have an admixture of water with it, which will progressively increase in quantity. In fact, the displacement of spirit by water is less complete than that of a tincture by spirit. In the latter case, as already stated, the porosity of the solid ingredients presents the principal impediment to the attainment of a perfect result; but in the former case, in addition to this, there are two other causes of obstruction. These are, first, the tendency to combination which exists between spirit and water; and, secondly, the tendency to change places, which the water and spirit will have under the circumstances of their position, in consequence of the greater specific gravity of the former. The whole of the spirit may, however, be recovered, partly in its original state of concentration, and partly diluted to a greater or less extent with water. This unavoidable dilution of the spirit during its recovery is a great defect in the process of displacement, for it generally happens that the recovered spirit is too much contaminated by the solid ingredients to admit of its being used for other purposes without being purified by distillation, and in its diluted state it cannot even be employed in repeating the process for the same tincture.

The preparation of *Essence of Ginger*, in the manner here described, affords a good illustration of the application of the process of displacement under favourable circumstances. The substance acted on may be used, as it ought to be, in the state of fine powder; this powder readily gives up the whole of its soluble constituents to spirit; when

moistened with spirit, it forms a mass through which percolation takes place with facility; and the extraction of the soluble parts does not cause much contraction of the volume of the solid matter. In cases where these conditions are not so well fulfilled, the application of the process will be less satisfactory, or some modifications of the process will be required. If the substance to be acted upon cannot be used in the state of fine powder, the interstices between the particles will necessarily be larger and more unequal, the pores and vessels contained within the particles will be more closed and confined, and the disparity between the size of the interstices and that of the pores and vessels will be greater; so that the liquid once absorbed into these pores and vessels will be removed with greater difficulty, while that occupying the interstices will flow with increased facility. If the soluble constituents are not easily extracted by the solvent employed, as is the case in treating *ergot of rye* with spirit, perfect exhaustion of the solid ingredients may not be effected in the time usually occupied by this process.

If the solid ingredients, when moistened with spirit, form a tenacious mass, the liquid will sometimes not percolate through this, or will percolate very slowly, so that it becomes necessary to mix the ingredients with coarse sand or pounded glass, to separate the particles and facilitate percolation.

Moreover, if the extraction of the soluble parts causes much contraction of the volume of the solid matter, it will be difficult, if not impossible, to prevent the formation of fissures through which the percolating liquid will almost exclusively run. In this case, an admixture of sand will lessen the evil.

The process, however, modified according to circumstances, may be applied, with greater or less advantage, in the preparation of most of the tinctures used in medicine, as stated by the authors of the "Edinburgh Pharmacopœia."

[The preparation of the resinous tinctures, as those of myrrh and guaiacum, is best effected by reducing those substances to pretty fine powder, and mixing them with an equal bulk of sand. It is requisite that the resinous powder should be equally diffused through the sand, otherwise the alcohol will pass, with unequal rapidity, through different portions of the mass. They should be carefully mixed in a dish, or on paper, and then introduced into the displacer with a spoon or capsule. If the mixture of sand and resin is emptied into the displacer in a stream, the superior gravity of the sand will separate it, to a certain extent, from the lighter resin.]

Spirit varnishes may readily be made in this way.—W. P.]

In reviewing the several advantages and disadvantages which attach respectively to the two processes which are recognised in the British Pharmacopœias, namely, *the process of maceration*, and *the process of displacement*, it would appear, on the one hand, that the objections to the process of maceration apply more strongly to its adoption on the small, than on the large scale; and, on the other hand, that the process of displacement is less applicable to operations on the large, than on the small scale.

When tinctures are made in large quantities, percolation is never likely to supersede maceration, on account of any practical advantages it may possess. If the prescribed directions be duly attended to, the process of maceration is unexceptionable. This process is more simple than the other; the mode of operating is more uniform,—it is, in fact, always the same; it requires less of skill and dexterity in conducting it; it requires less constant attention during its progress, which, in operating on large quantities, is a consideration; and, finally, the apparatus required is less complicated.

When only small quantities of tincture are made at a time, and kept in stock, the adoption of the process of displacement will often be found convenient and advantageous. It offers the means of making a tincture in two or three hours, which by the other process would require as many weeks. The process being thus completed in so short a time, for the quantity contemplated might be made at one operation, it would not be so likely as the other to experience neglect during the performance of it, or a deviation from the prescribed instructions; the product would therefore be more uniform. Finally, in many cases, the tincture and spirit may be removed from the dregs more completely, in operating on small quantities, by this process, than by the other.

Even in those establishments where tinctures are generally made by maceration, the process of displacement will be found useful as a resort in cases of emergency, and for the preparation of some particular tinctures.

[In preparing formulæ for tinctures, by whatever process, one of the most important points is to know what strength of alcohol is most appropriate for individual cases. This question was so well appreciated by the Society of Pharmacy at Paris, that they offered their prize of 1000 francs for its solution, which was gained by M. Personne. In the *Codex* most of the tinctures are saturated, whilst in the United States and British formulæ the alcoholic menstruum is in great excess

in most of them. The importance of attention to the point in view is exemplified in the recipe for tincture of jalap in the U. S. P. M. Personne has shown that five parts of alcohol, containing 80 per cent. of absolute alcohol, was necessary to extract, and hold in solution, the resinous matter of one part of jalap; whilst the formulæ alluded to directs but four parts of alcohol, containing only 42 per cent.; hence nearly half the resin must be left in the refuse dregs.

Tinctures are very liable to vary in medicinal strength. As the quantity of material is arbitrary, it follows that any variation in the activity of the drug will influence the tincture. If it were possible to know the precise strength of each specimen of a drug, allowance could be made for deficient strength, by increasing the quantity. As this is impossible in the majority of instances, the only remedy is a conscientious endeavour to get, and use, the best drugs for this purpose. Another cause of variableness, when good drugs are used, is neglect of garbling, or the separation of accidental impurities or inert parts. The leaf-stalks of digitalis and tobacco, and the stalks of aconite and belladonna, may be instanced.

Tinctures, although the most stable of vegetable solutions, gradually undergo changes by age, light, and exposure. Some, like tincture of myrrh, are bleached, others grow darker; some deposit insoluble matter, as the tinctures of cinchona, sanguinaria, &c., whilst astringent tinctures of the kino class, lose their astringency and gelatinize, a change due to the action of the air. The exact degree of injury induced by these influences, would form an interesting subject for investigation if patiently followed by chemical and therapeutical experiments.

PRESERVED JUICES, OR ALCOOLATURES.—M. Beral, some years since, proposed a class of tinctures of narcotic plants, in which the water of vegetation of recent juices acted as the water of dilution of the alcohol. There are two ways of proceeding—one by adding alcohol to the bruised plants, macerating and expressing;—the other is to express the juice, and add sufficient alcohol to it to preserve it. The latter is the plan of Mr. Squire, of London, who, under the name of preserved juices, introduced these tinctures to the attention of English pharmacutists. The juice, obtained at the time most favourable for the development of the virtues of the plants, is mixed with half its weight of alcohol, and after a time filtered. Wormwood, taraxacum, and the narcotic plants, are thus treated. The advantage proposed to be gained by these preparations is, that the active constituents of the plants are unchanged by the process of drying. Owing to the variable proportion of water in the juices of the same plant, at differ-

ent times, they are liable to vary in strength from this cause. Mr. Redwood found that the juice of *lactuca sativa* had the sp. gr. 1·031 in the evening, and 1·026 the following morning.

MEDICATED WINES are tinctures in which the menstruum is wine. The variety called white wines are preferable for these preparations, as they contain about 20 per cent. of alcohol. Madeira, sherry, and Teneriffe, are the wines usually employed. Wines are made by maceration, and displacement. It has been objected to the application of the displacement process to these liquids, that the wine cannot be displaced by water without partial mixture. This objection is not valid, as, after the proportion of wine has been used, a little more can be added, followed by weak alcohol.

In making the wines of ergot and *ipeacuanha*, their powders should be mixed with an equal bulk of sand, and displaced without maceration. In the case of wine of *colchicum* root, the operation should be preceded by a maceration of seven days.

Medicated wines are not so permanent as tinctures, and those of *ipeacuanha* and *colchicum* root are especially liable to deposit insoluble matter by standing, a change which is facilitated by exposure to light.

MEDICATED VINEGARS are solutions of the soluble matter of plants in distilled vinegar, or diluted acetic acid. The advantages of acetic acid as a menstruum are, its solvent power, and its antiseptic quality. Distilled vinegar is the form of acid prescribed by the United States Pharmacopœia, and it should possess such strength that a fluid ounce will require thirty-five grains of bicarbonate of potassa to saturate it. In plants containing alkaloids, as *colchicum*, it probably facilitates the solution of those principles by forming soluble salts. It is usual to add one-thirtieth of alcohol, but it would be more philosophical to add that quantity of strong acetic acid. The medicated vinegars are properly made by displacement, especially those of squill and *colchicum*. They are not so permanent as tinctures, and should be kept in the dark.

OILY SOLUTIONS.—The fixed and volatile oils are used as menstrua for extracting plants, and dissolving principles, with a view, generally, to their use as external applications. In European pharmacy, *belladonna*, *hyoscyamus*, *conium*, *stramonium*, and other narcotics, are treated by mixing the bruised recent plants with olive oil, and heating them until all the water of vegetation has evaporated, and the oil has dissolved sufficient of the chlorophylle of the leaves to acquire a green colour. The ointments of *mezereum*, *stramonium*, and tobacco,

of the U. S. Pharmacopœia, are made in this manner, lard being substituted for the oil. Cantharides, mezereum, and euphorbium, are thus treated to make stimulant and rubefacient liniments. Phosphorus and camphor are also dissolved in oil.

SACCHARINE SOLUTIONS—SYRUPS.—In placing medicated syrups under the head of saccharine solutions, it is because the basis of them is a definite compound of sugar and water, which may be looked upon as a vehicle for the administration and preservation of certain medicines, just as wine or vinegar perform the same part,—though it should be distinctly understood that the syrup does not act as a solvent; the sugar being added after the medication of the aqueous liquid. The design of the sugar, therefore, is to preserve vegetable solutions and juices from spoiling, to avoid the stimulating effect of alcohol in permanent liquid preparations, and in certain cases to protect chemical solutions from oxidation.

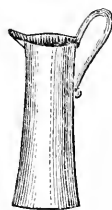
All liquids capable of dissolving more than their weight of sugar, will admit of being made into syrups. These are water, the distilled waters, emulsions, and gummy solutions, aqueous solutions of extracts, cold and hot infusions, decoctions, juices, vinegars, hydro-alcoholic tinctures deprived of alcohol by evaporation, and finally, wines.

PREPARATION OF SIMPLE SYRUP.—The pharmacutists of continental Europe are accustomed to prepare simple syrup in large quantities, from impure sugars, and subsequently use it for medicated syrups; but the low price of the purest sugar, in the United States, supersedes the necessity for this species of economy, and enables us to leave the purification of the crude material to the sugar refiners. There are three methods of making simple syrup, depending on the quality of the sugar from which it is made. *First*, by dissolving pure sugar in half its weight of water, by agitation without heat, or with a gentle heat, which is the process of the Pharmacopœia. It is sometimes rendered absolutely colourless, by agitation with one-twentieth of its weight of animal carbon in distinct grains, and strained. In the *second* process, the syrup is made from second quality loaf sugar, by clarification with albumen. Twenty pounds of sugar, eleven pints of water, and the albumen of one egg, are employed. The albumen is dissolved in the water; ten pints of the solution is poured over the sugar, in a suitable kettle, and placed on the fire, stirred occasionally till the sugar is entirely dissolved, and then heated rapidly to ebullition. The coagulated albumen is then removed by skinning, the syrup again made to boil, and the remaining pint of albuminous water

thrown in at intervals, until, on examining the solution, it consists of a transparent liquid with well-defined flocculi floating through it.

The density of the syrup is then ascertained with the saccharometer, fig. 46, by filling the test-cup, fig. 274, and placing the instrument in it, when it should mark 30° at the boiling temperature. If it does not reach this point, continue the ebullition a few minutes; if above it, add a little water. The vessel is then removed from the fire, and its contents strained through the conical bag of cotton or woollen flannel before described, (fig. 191.) Simple syrup thus prepared, always has a yellowish colour, but is perfectly transparent.

Fig. 274.

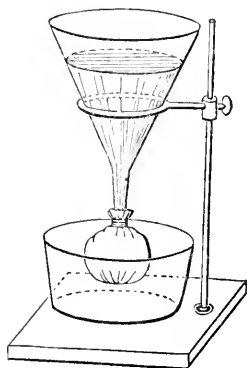


SACCHAROMETER CUP.

The straining of syrups is an important feature in their manufacture. The several media and modes of constructing filters and strainers from them, have been treated of under the head of FILTRATION. The large operations of the sugar refinery are best conducted with Taylor's plaited tubular filter, described at page 192. Whatever form, whether this or the conical bag, or simply a square cloth, be adopted, the under surface of the filter should be enclosed in a suitable space or vessel, to prevent evaporation, and the consequent clogging of the filtering surface.

It sometimes happens that very small quantities of syrups are to be strained. A very convenient and economical way of doing it, is to gather up the edges of a circular piece of Canton flannel, or other suitable material, moistened with water, and tie it securely around the neck of a funnel, in such a manner as to form a small globular bag, as at fig. 275. The syrup to be strained is then poured into the funnel, the height of the column of fluid causing it to pass rapidly through the tissue. The bag should be enclosed in the receiving vessel, to prevent evaporation from its surface.

Fig. 275.



The *third* process for simple syrup applies to the more common kinds of imported sugars, as Brazil, Havana, &c., and involves the operations of *clarification* and *decoloration*. There are two methods. In the first, sixty pounds of the sugar, thirty-five pints of water, the albumen of four eggs, and four pounds of washed animal charcoal,

may be taken. The albumen is dissolved in the water; the sugar, the charcoal, and twenty-four pints of the albuminous water, are placed on the fire, and stirred constantly until the sugar is dissolved, and then boiled to coagulate the albumen, which, in assuming the solid state, entangles the carbon, and renders the syrup comparatively clear. After skimming, the remaining water is added at intervals, boiling after each addition, until the syrup is transparent, and marks 30° of the saccharometer, when it is strained. In the second method, the syrup of impure sugar is clarified by albumen, and passed whilst hot through Dumont's charcoal filter, or the apparatus fig. 227, when the quantity is small. The charcoal used for syrup should be washed with a little muriatic acid, to deprive it of the sulphurets of calcium and iron, which sometimes communicate a disagreeable taste to the syrup.

MEDICATED SYRUPS.—The chief difference between the preparation of simple syrup and the medicinal syrups is, that in the former, the vehicle, water, is always at hand, whilst in the latter, the medicated liquid often requires a complex and tedious process, before it is ready for the sugar. Most of them are composed of water holding in solution solid matter, the result of treating drugs by maceration, infusion, decoction, or displacement. Some by evaporation of tinctures, as syrup of sarsaparilla, of ipecacuanha, and of poppies. The means of obtaining these liquids have been fully noticed in speaking of the methods of solution.

The process of dissolving the sugar in these solutions, varies with their nature; some require the sugar to be in coarse powder, and shaken with the fluid until dissolved, as in the syrups of wild cherry bark, valerian, and orange-flower water. In some a moderate heat, of 150° Fahr., is employed, so that albumen may not be coagulated, as in the almond syrup; or volatile principles not be dissipated, as in the syrup of chamomile or roses; but most of them admit of being heated to ebullition. In making light-coloured syrups, the darkening influence of continued heat on sugar should be avoided as much as possible.

Medicinal syrups are sometimes made by dissolving active medicines in simple syrup, as the salts of quinia and morphia, hydrocyanic acid, sulphuric ether, &c.

In making syrups from aromatic tinctures, as those of ginger, balsam tolu, orange peel, &c., the sugar should be reduced to a coarse powder, the tincture poured over, and mixed with it, and the sugar

thus impregnated spread out on paper in a warm place, until the alcohol evaporates. The dry aromatized sugar is then mixed with half its weight of water, and made into syrup with a moderate heat, in a covered vessel, and strained. This method is far preferable to mixing the tinctures with the syrup, and evaporating the alcohol by heat.

There is sometimes, however, a decided advantage in evaporating the alcohol from hydro-alcoholic tinctures after admixture with the sugar, instead of doing it before, as the sugar retains certain principles in solution, which would otherwise be precipitated, and besides preserves them from oxidation.

SYRUPS OF VEGETABLE JUICES.—The juices of certain vegetables, as asparagus and scurvy grass, and of fruits, as strawberries, pine-apples, lemons, &c., form the basis of a class of syrups. The latter are largely prepared by American pharmacutists, for admixture with carbonic acid water as a beverage, and as adjuvants to extemporaneous mixtures.

The fruit for this purpose should be entirely ripe. Strawberries, raspberries, and those of this kind should be enclosed in flannel or cotton sacks, without previously bruising, several of which should be placed in a pile, and submitted to a gradual pressure, that the juice may run out clear without any vegetable pulp, (as will occur if the expression is violent,) and continued until the juice is extracted.

It is usual in making these syrups, to take a quart of fruit to a quart of syrup. After expressing the juice from thirty quarts, it is measured, and as much water added as will make thirty pints. This is placed in the syrup kettle with sixty pounds (avoirdupois) of the purest sugar, and heated, with frequent stirring, until it commences to boil, when it is removed from the fire, skimmed, and strained.

A more delicately flavoured syrup may be made by dissolving the sugar in the water, and a part of the juice by heat, then throwing the remaining juice in the boiling and concentrated syrup, and after heating it a few minutes, skimming and straining it. Sometimes the fruit itself is thrown into a boiling, very concentrated solution of sugar, and after a few minutes' contact the whole poured on a filter. Thus made, the syrup possesses the aroma and taste in perfection, but does not keep as well as the preceding.

Pine-apple syrup is made by paring and slicing the ripe fruit, placing four pounds (avoirdupois) of the slices in alternate layers, with three pounds of sugar, and allowing them to remain twenty-four hours in a cool place. It will be found that the sugar has been dissolved

at the expense of the juice of the fruit, the fibrous portion of which floats on the solution, and should be removed and expressed. The residue is then treated with hot water and again expressed, the last liquid is added to the syrupy juice, and the whole measured. Now as the space occupied by a pound (avoirdupois) of sugar, when in solution in water, is just *half a pint*, it follows that a pint and a half must be allowed for the sugar. As the quantity of syrup to be made from the four pounds of pine-apple is ten pints, five pints of juice and water together is requisite, and the operator will therefore add water to the syrupy liquid obtained as above till it measures six and a half pints. The balance of the sugar, viz., seven pounds, is then added, and dissolved by a heat of 150° Fahr., in a covered vessel, and strained.

Pine-apple syrup made in this way, retains the delicate flavour of the fruit, and keeps as well as the boiled syrup, if bottled warm and carefully sealed.

Syrups intended to be kept, especially fruit syrups, should be bottled while hot, securely corked and sealed, and after cooling, should be shaken, that the moisture condensed on the cork may be mixed with the syrup, and not form a diluted layer at the surface.

A solution of absolutely pure sugar undergoes no change by keeping, but medicated syrups, and even simple syrup, tend to experience alteration by age, which is generally due to the presence of nitrogenous matter. If, however, syrups are perfectly transparent, of the concentration of 35° or 36° Baumé, and are kept at the temperature of 60° Fahr., in securely stopped bottles, they rarely undergo change before they are wanted for use in the ordinary demands of business. There are, perhaps, some few exceptions,—syrup of gum arabic and *orgeat*, for instance. Chlorate of potassa, sugar of milk, and ethereal liquids have the power of preventing fermentation, but it is not always admissible to make such additions. One fluid drachm of Hoffman's anodyne per pint of syrup, will effectually check a tendency to fermentation.

MELLITES are syrups, in which honey takes the place of the sugar in ordinary syrups. Most of the honey of commerce requires to be purified before it is fit for the purposes of pharmacy. That derived from the *West Indies* is dark-coloured, and needs clarifying or decolorizing.

Honey may be rendered absolutely colourless by passing it through the charcoal filter, fig. 227, after having diluted it with half its weight of water, which is subsequently removed from the honey by gentle

evaporation; or the charcoal, with a little chalk to saturate a slight acidity characteristic of commercial honey, may be heated with the honey, and before it commences to boil, some albuminous water thrown in, mixed through the honey, and then the whole carried to ebullition, skimmed and strained.

Medicated Honeys are prepared by mixing an aqueous or acetic solution of the medicinal substance with the honey, and evaporating until it has the sp. gr. 30° B. They are less esteemed than syrups.—W. P.]

CHAPTER X.

EVAPORATION. THE CONCENTRATION OF LIQUIDS. THE PREPARATION OF EXTRACTS. DESICCATION.

[VAPORIZATION, as applied in pharmacy, has several objects :

1st. When designed to separate a volatile liquid from a solid, with a view to the solid substance, or one liquid from another, to obtain the less volatile, it is called *evaporation*.

2d. When employed to separate a liquid from either a less volatile liquid or a solid, with a view to the volatilized liquid, the process is called *distillation*.

3d. When used to isolate a volatile solid, from either a liquid or solid that is more fixed, the operation takes the name of *sublimation*.

Evaporation is extensively resorted to in pharmacy, in the concentration of liquids for syrups or extracts ; to effect the crystallization of saline and other bodies when in solution ; and to effect the desiccation of herbs, and parts of plants, precipitates, lozenges, &c. Before explaining the methods which have been adopted for facilitating evaporation, it will be useful to state a few of the laws or rules which influence it favourably or otherwise.

1st. The quantity of vapour which will form in a given space is *constant for the temperature*, and when such space is saturated, evaporation ceases, unless some circumstances concur to remove a portion of the vapour by condensation ; as where lime, placed under a bell glass with diluted alcohol, absorbs the aqueous and rejects the alcoholic vapour.

2d. The rapidity of evaporation is influenced by the state of saturation of the air, being inversely as the quantity of vapour existing in the air, when the liquid does not boil.

3d. When a homogeneous liquid has arrived at its boiling point, its temperature remains stationary until the whole of the liquid has vaporized, provided the atmospheric pressure remains the same. But if solid matter is in solution, the temperature of the liquid gradually

rises until the point of saturation is attained—a fact illustrated in the evaporation of solutions of saline matter by boiling.

4th. The boiling point of liquids is affected also by the cohesion of the liquid, the depth of the fluid heated, and the nature of the vessel used. Shallowness favours ebullition by decreasing pressure, and vessels made of good conducting substances, (as the metals,) with rough interior surfaces, are better for boiling rapidly than smooth glass or porcelain ones. The retarding effect of cohesion in the ebullition of liquids is described in the chapter on DISTILLATION.

5th. In evaporation below the point of ebullition, the temperature, pressure, and other circumstances being equal, *the amount of vapour formed, is in direct ratio to the extent of surface exposed to the air*, and not to the quantity of the liquid.

6th. In evaporation by boiling, the formation of vapour is in direct proportion to the surface exposed to the fire, or heating agency, a fact taken advantage of in the construction of tubular steam boilers; and, according to Dr. Ure, every square foot of such surface evaporates 725 grains of water per minute, without relation to the surface exposed to the air.—W. P.]

Evaporation may be effected:

1. By the direct radiation of heat from a fire upon the bottom of an uncovered evaporating pan or dish. This is called *evaporation over the naked fire*.

2. By the conduction or convection of heat to the pan, through the medium of water or steam. This is called *evaporation by the water-bath or steam-bath*.

3. By the application of heat by either of the foregoing methods, together with the removal of atmospheric contact and pressure from the surface of the evaporating liquid. This is called *evaporation in vacuo*.

4. By the spontaneous diffusion of the vapour of the liquid into the atmosphere, assisted by a current of air passing over the surface of the liquid. This is called *spontaneous evaporation*.

[*Evaporation over the naked fire* is best resorted to when the substance in solution is not injured by direct heat, and it has chiefly reference to concentrating saline solutions, for crystallization or to dryness. In evaporating saline solutions to dryness in capsules by direct heat, as for instance citrate or carbonate of potassa, it is necessary to stir them constantly, as soon as the liquid begins to thicken, to prevent the incrustation of the bottom, and the fracture of the vessel. When pressure steam-heat can be used this is avoided.

The best evaporating vessels for pharmaceutical purposes, where nicety is required, are those of Berlin porcelain. They resist sudden alternations of temperature better than any other earthen vessels, and may be had from two ounces to two or three gallons capacity. English and French evaporating dishes are much more readily fractured by heat, and are often permeable by coloured fluids. Well-tinned copper pans are the most generally used for neutral liquids; they conduct heat better than any others, and withstand the rough usage to which such vessels are liable.

For the evaporation of solutions of caustic potash and soda, silver vessels are to be preferred, and one of this metal or platinum will always be found useful in the pharmaceutical laboratory.

Cast-iron dishes, lined with enamel, are made for evaporating purposes, and with careful treatment they afford a good substitute for the Berlin porcelain; but the different expansibility of the enamel and iron, soon causes the former to chip off and crack, unless the heat is applied with care.

Common earthenware vessels may be used on many occasions when heated by a sand-bath.

Sometimes saline solutions are liable to be injured by dust during evaporation, as those of nitrate of silver and chloride of gold. These may be concentrated by boiling in flasks, or dishes covered with a funnel or glass plate.

Further remarks relative to the concentration of saline solutions will be found under the head of CRYSTALLIZATION.

In the concentration of solutions of vegetable matter, with a view to using them for syrups or fluid extracts, the same care should be observed as when these liquids are designed for solid extracts; and as a large amount of the evaporation in pharmacy relates to such liquids, the precautions, directions, and apparatus to be described for the preparation of extracts will be applicable to these.—W. P.]

EVAPORATION OF SOLUTIONS FOR EXTRACTS.

In the preparation of extracts, the quality of the product will depend less upon the means adopted for extracting the soluble matter from the vegetable substances operated upon, than upon those by which the inspissation of the solutions is effected.

An *extract*, for medicinal use, ought to contain the active constituents of the substance from which it is made, if possible, in an

unaltered condition. It should represent the infusion, decoction, tincture, or juice, by the evaporation of which it is obtained, in every respect, excepting the state of concentration of the active ingredients, and the permanency of their condition.

Extracts are, or ought to be, composed of a number of chemical constituents, or proximate vegetable principles, *educated* and not *produced*, during the process of preparation. Among these constituents are, starch, gum, sugar, pectin, albumen, gluten, vegetable acids, alkaloids and allied bodies, oils, resins, and colouring matters. These substances are very liable to undergo decomposition or changes of constitution, especially when exposed to the action of heat and atmospheric air; and it is with the view of preventing these changes that different modifications of the process of evaporation in making extracts have been proposed.

Evaporation over the naked fire, is sometimes resorted to where rapid concentration is required. Where a large quantity of decoction or infusion has to be inspissated to the consistence of an extract, it is not unusual to adopt this method of concentrating the liquor in the first instance, before resorting to the use of the water-bath. This indeed is the mode of proceeding which is prescribed by the London College, in the preparation of many of the extracts ordered in the Pharmacopœia. Thus, the extracts of gentian, liquorice, hop, poppy, sarsaparilla, dandelion, &c., are directed to be made by macerating the vegetable ingredients in boiling water for twenty-four hours, then boiling down to one-half, straining the liquor while hot, and finally evaporating to a proper consistence in the water-bath. In these cases it must have been intended that the boiling down to one-half should be performed over the naked fire; for the liquors could not be boiled in the water-bath, which is the only other process alluded to in the Pharmacopœia for the preparation of extracts.

This method of evaporation, however, is subject to great objections, although, certainly, these do not apply so strongly in reference to the first concentration of the liquors, as to the subsequent inspissation of the extract. Yet, in every stage of the process, evaporation over the naked fire, with an uncased open pan, is liable, in unskilful hands, to result in the injury, if not destruction, of the properties of the product. It cannot be denied, indeed, that a skilful and experienced operator will often effect all that can be desired with these means of evaporation, but with deficiency of judgment, or want of attention and care, an opposite result would inevitably be attained.

[The rationale of the action of direct heat on a solution of organic matter, appears to be this. When a concentrated solution obtained by displacement, for a syrup or extract, is in a state of active ebullition over a naked fire, the whole inner heated surface of the boiler is studded momentarily with bubbles of steam. The upper and lateral surface of each bubble presses against the superincumbent liquid, whilst its base, composed of a thin stratum of the solution, is in contact with the heated surface of the boiler for an instant, during which its solid contents are scorched by the sudden accession of heat. As the bubble rises, the surrounding fluid rushes into the space vacated by it, and dissolves the concentrated and scorched matter. The same phenomena are repeated an infinite number of times, until the whole of the solid contents of the liquid becomes more or less affected.—W. P.]

In evaporating a liquid over the naked fire, especial attention should be paid to the condition of the fire, and the position of the pan in reference to it. The pan ought in no case to be in contact with the ignited fuel: the heat received by the pan should be that of radiation, not of conduction. There should even be a considerable distance between the bottom of the pan and the surface of the fire, especially when the extract begins to thicken; the fire should now, also, be clear and low, so that an equable and not too intense heat may radiate upwards. Moreover, in operating in this way, it is not desirable to have a very small quantity of extract in the pan at a time, as in this case it would be more difficult to avoid the application of undue heat.

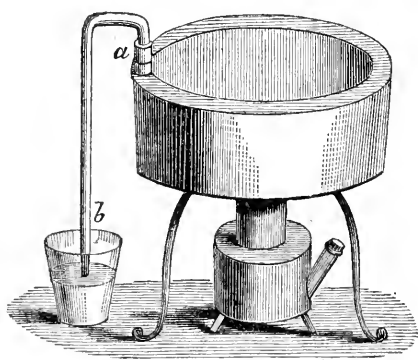
Evaporation by the water-bath, or steam-bath, has almost wholly superseded the process last described, and is the method now generally adopted in the preparation of extracts. The water-bath and the steam-bath are here classed together, because they have some characters in common; but in the practical application of these two means for effecting evaporation, it will be found that they differ from each other in some important particulars.

The water-bath is an arrangement by which the heat of boiling water is applied to the outer surface of the vessel containing the evaporating liquid. Thus, a double or jacketed pan, with the intermediate space between the pan and its outer case partly filled with water, constitutes a water-bath. If this be placed over a fire, the temperature of the water in the jacket rises to the boiling-point, and all excess of heat beyond this passes off in the steam, which has free means of escape. The greatest amount of heat, therefore, applied to the *outer surface* of the pan containing the evaporating liquid is 212° ;

and as the metal of which the pan is composed offers some obstruction to the passage of the heat through it, the liquid within will only attain to a temperature a few degrees *below* the boiling-point. Hence water cannot be boiled in a water-bath, and the evaporation which takes place under these circumstances is confined to the surface of the liquid.

[Fig. 276 represents a water-bath constructed of tinned iron, which may be made at small cost, and is as convenient in use as an ordinary pan. Tinned copper affords a more permanent vessel. The water is introduced at *a*, and its temperature may be raised above 212° Fahr., by causing the tube *b* to dip into a glass of mercury. When the mouth *a* is corked, after removal from the fire, the contents of the evaporator may be poured out, as from a pan.—W. P.]

Fig. 276.



In the *steam-bath*, the steam is employed under pressure, and consequently at a temperature above 212°. Thus, the temperature will be 226° Fahr., if the pressure be five pounds to the square inch; and, rising with increase of pressure, it will be at about 233° when the pressure is seven pounds and a half, and 240° when the pressure is ten pounds to the inch. Now, steam at a pressure of five pounds to the inch, when applied to the outer surface of the pan, will heat the liquor contained in the pan to the boiling-point, and therefore a steam-bath with steam at the lowest of the above temperatures, by maintaining the evaporating liquor in a state of ebullition, will effect much more rapid evaporation than the water-bath will.

In the inspissation of extracts, when the process is conducted in vessels open to the access of atmospheric air, it is important to effect the required evaporation rapidly, and without the application of a high temperature. In the water-bath the temperature is lower, but the rate of evaporation is very much less rapid than it is in the steam-bath. When evaporation takes place at a temperature below the boiling-point of the evaporating liquid, as is the case with the water-bath, the rate of evaporation depends on the extent of surface of the liquid exposed to the air, on the temperature of the liquid, and on the temperature

and state of dryness of the air which is in contact with it. The reduction of a few degrees in the temperature of the evaporating liquid below the boiling-point occasions a great diminution in the rate of evaporation, as will be seen in the following table:—

Temperature.	WATER.	Rate of Evaporation.
212°		512
180°		256
150°		128
125°		64
100°		32
79°		16
58°		8
38°		4

When evaporation takes place at the boiling-point, and therefore accompanied with ebullition, as is the case with the steam-bath, the rate of evaporation depends, principally, upon the extent of surface to which the heat is applied.

The more rapid evaporation obtained by the steam-bath, gives to this method of operating a great advantage over the water-bath; the ill effects of the slight increase of temperature being more than compensated for, by the diminution of time during which the extract is exposed to the combined influences of heat and atmospheric air. It must be observed, however, that the steam-bath cannot be safely and advantageously used in the preparation of extracts, if the steam be under a pressure much above five pounds to the inch, and in some cases it is desirable to have it even less compressed than this. The temperature of steam under a pressure of ten or twelve pounds to the inch would materially injure the product, especially in the latter stage of the process.

The steam-bath offers great facilities for regulating the temperature, by the admission of more or less steam into the jacket, or, if necessary, by its total exclusion, which may be effected instantly. In this way the heat is completely under the control of the operator, and a little skill in the management of the valves, and in manipulation, will enable him to guard against the injuries resulting from its injudicious application. When steam under pressure is used, it is not desirable to operate upon a very small quantity of extract at a time, for the reason that has already been assigned in treating of *evaporation over the naked fire*. It will also be found that a pan that is rather deep will be preferable to one that is very shallow. It is even necessary to

observe some caution in the use of the rotating stirrer, or agitator, (fig. 133,) for if there be not much extract in the pan, this, by the rapid rotation of the agitator, would be spread in a thin stratum over the surface of the sides of the pan, where the metal is at a higher temperature, and the heat thus applied, together with the extended contact with atmospheric air, would cause speedy decomposition of the vegetable principles present. In preparing the extracts, or inspissated juices, which have a green colour, from the presence of chlorophylle, if they be treated in this way, the colour will be almost instantly destroyed.

In making the extracts of henbane, hyoscyamus, aconite, and others of this description, the practice is frequently adopted, of collecting the chlorophylle, or green colouring matter, which separates together with the albumen on first heating the expressed juice, by passing the liquor through a sieve or other strainer. This is kept excluded as much as possible from the air and light, until the remaining part of the juice has been inspissated, and it is then mixed with the extract to give it the green colour, which is, by many, considered a test of its good quality. This practice may serve for the deception of those to whom the extract is sold, but it can answer no good purpose. The chlorophylle itself possesses no medicinal activity, and its rejection altogether has been proposed by some pharmacutists, with a view to the improvement of the extracts. If, however, it be retained, as is directed in our pharmacopœias, it should be subjected to all the influences to which the other parts of the extract are exposed, so that it may serve as an indicator of the care and judgment which have been exercised during the process of evaporation; for as this substance is very easily decomposed, and its green colour destroyed, by those agencies which cause the decomposition of other more active constituents of the extract, its unaltered condition, if it have remained present during the whole process, will afford good grounds for assuming that the extract in other respects is uninjured.

Evaporation in vacuo, affords the most perfect means for the preparation of extracts. The sources of deterioration to the product, which the other methods present, are not found here, if the proper arrangements be adopted. By enclosing the liquor to be inspissated in an air-tight still, and removing the air from the interior of the vessel, evaporation is rapidly effected at a much lower temperature than that employed in either of the processes hitherto noticed, and without the possibility of injury from the contact of the atmosphere. The only obstacle to the general adoption of this method arises from the

great expense of the requisite apparatus. Mr. Barry first introduced the use of the *vacuum-pan* in the inspissation of extracts; but the apparatus and mode of operating which he recommended, and for which a patent was taken out, has not been found, practically, to be the best. My attention was directed to this subject some years ago, and the result of experiments then made has convinced me that the form of apparatus now so extensively employed by the sugar-refiners for the concentration of their syrups might be advantageously applied to the preparation of medicinal extracts. This apparatus consists essentially of an air-tight still, to the receiver or condenser of which a pump is attached, which is kept in constant action. By this means the apparatus is first exhausted of the air, and the condensed water and steam are subsequently pumped out as fast as they collect in the receiver. The apparatus which I principally employed in my experiments is represented in fig. 277. It was originally made as a model of a sugar-pan, and is adapted for working about fifteen gallons of liquor at a time. The drawing, however, differs in some respects from the arrangements now generally adopted by the sugar-refiners. The neck (F) is now usually made much shorter and thicker than the drawing represents, and the perforated funnel (I) is dispensed with, the steam itself being pumped into a cistern of water, where it is condensed. It would also be desirable to have the steam-chamber (B) much more capacious than it is here represented.

The liquid to be inspissated is put into the pan at E, and the cap fitted on. The steam is now admitted into the steam-chamber, and the air exhausted from the interior of the apparatus by means of the pump. A vacuum being produced, active ebullition will take place when the temperature rises to about 120° Fahr. The vapour passes up the neck (F) and through the descending pipe into the cylinder L. A jet of cold water is now allowed to run at *f*, and is dispersed in a shower by means of the perforated funnel (I), assisting to condense the steam in its passage into L, from whence it is removed, together with the condensed steam and any air remaining in the apparatus, by means of the pump. The pumping is continued until the completion of the process, and thus a pretty complete vacuum is maintained, and a rapid evaporation insured.

As the loss of some of the contents of the pan may arise from their boiling up through the neck (F), and being carried off by the pump, a glass tube (G) is made to communicate between the pan and the upper part of the neck, so that when the liquid is seen to rise in this tube, the pumping is immediately stopped, and, if necessary, air is admitted

into the pan by the stop-cock *d*, which effectually suppresses the ebullition. No more water should be admitted through the perforated funnel (I) than is sufficient, with the external application of cold water to the cylinder, for the condensation of the steam. This is ascertained from the temperature of the descending steam-pipe and the upper part of the cylinder. The admission of too much water would tend to destroy the vacuum, by supplying air to the interior of the apparatus.

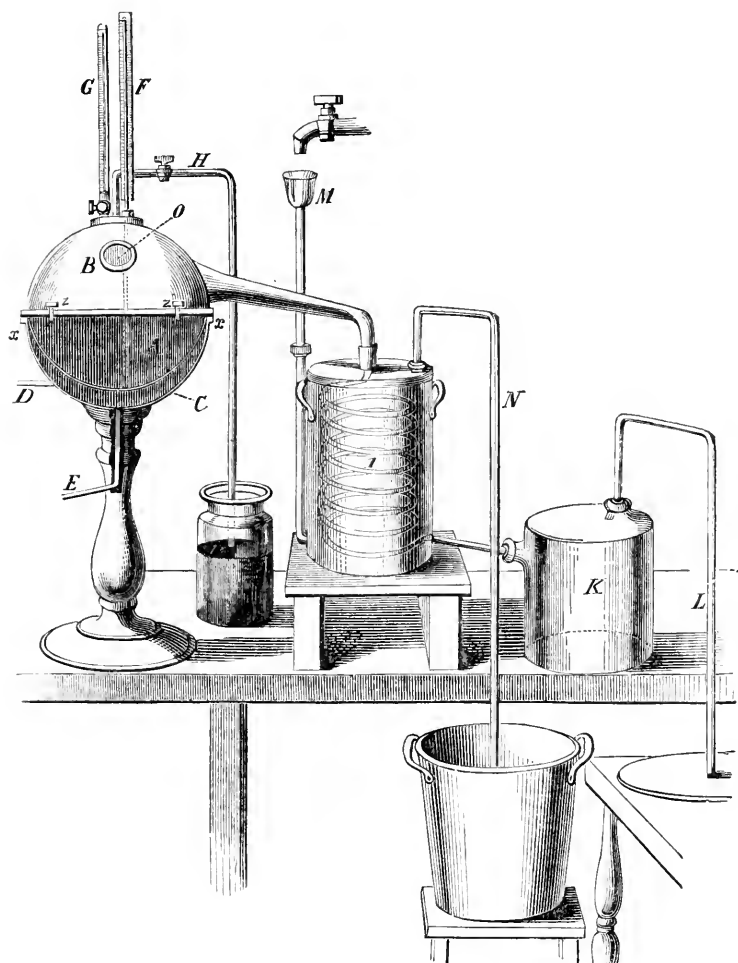
The steam used for heating the pan ought not to be under a pressure of more than one or two pounds to the inch, and there should be a plentiful supply of it. The amount of heat carried off during evaporation is precisely the same in this process as it would be if conducted under the pressure of the atmosphere at a much higher temperature, for at whatever temperature the vapour of water rises, the sum of its sensible and latent heat is always the same. Thus,

Water evaporating at	32°	has	1180°	of latent heat	=	1212°
"	"	100°	"	1112°	"	= 1212°
"	"	212°	"	1000°	"	= 1212°
"	"	300°	"	912°	"	= 1212°

It will therefore be evident, that, in evaporating a liquid, exactly the same amount of heat is always required, whatever process may be adopted; whether it be by boiling under the pressure of the atmosphere, by spontaneous evaporation, or evaporation *in vacuo*, in each case the heat required for the vaporization of a given quantity of liquid will be the same, and this quantity for water will be equal to 1212°, as the amount of sensible and latent heat. Fig. 278 represents a similar apparatus, which I have been accustomed to use for experimental purposes: it will serve to illustrate the essential parts of a vacuum-pan in its most simple form. A, is a jacketed pan supported on a cast-iron stand. There is a thick brass flange to the top of this pan at *x x*, which is ground to a smooth surface in the same way as the plate of an air-pump is. The top or head (B) also has a similar flange, which is ground so as to fit closely on to that of the pan. Between these two flanges is placed a washer of *vulcanized India-rubber*, which is compressed by four screws, two of which are seen at *z z*, and a perfect air-tight union is thus made, which may be disconnected and re-formed with very little trouble. Before trying the *vulcanized India-rubber*, I found it very difficult to make a sound temporary joint between the pan and its cover, without using some substance the presence of which was objectionable. Common India-rubber cannot be used, on account of the action of the heat upon it, but when vulcanized,

it is no longer affected by the heat to which it has to be subjected, and in every respect it fulfils all that is desired. The *vulcanized India-rubber* is sold in sheets about the sixteenth of an inch in thickness, out

Fig. 278.



VACUUM APPARATUS.

of which the washer must be cut in one piece, allowing a little for its expansion when compressed. Two circular plates of thick glass are inserted on two opposite sides of the cover of the pan, as shown at *O*, so as to enable the operator to observe the progress of the inspissation in the pan. The neck is fixed to the head of the pan in such a manner

that, by means of a groove inside the head, just above the flange, whatever vapour is condensed in the head is carried off by the neck, instead of returning to the contents of the pan. The beak of the neck is attached by an air-tight joint to a condenser (I); and the lower end of the worm of this condenser is inserted into a two-necked bottle (K), from the other opening of which a tube (L) is carried, which is attached to a good air-pump. At the top of the head of the pan there is a brass plate with three openings, through which the thermometer (F), the barometer or pressure-gauge (G), and the syphon (H) are inserted by means of perforated corks. The bulb of the thermometer passes to the bottom of the pan, so as to indicate the temperature of the evaporating liquid. The pressure-gauge indicates the degree of exhaustion of the interior of the apparatus; and the syphon serves to supply fresh portions of liquid to the pan, from any vessel into which the lower end of it is immersed, by opening the stop-cock, during the progress of the evaporation, without affecting the vacuum.

The liquid to be evaporated being introduced into the pan, and the joints all made tight, exhaustion is effected by the pump, which communicates with the receiver (K), the worm of the condenser (I), and the interior of the pan (A). When the mercury in the pressure-gauge has been reduced to a column of four or five inches, steam is conveyed through the pipe D, to the steam-chamber (C), while the water which collects here from condensation is carried off by the pipe E. The action of the pump should now be resumed, and continued throughout the process. The liquid, if aqueous, will commence boiling when heated to about 120° Fahr., and the evaporation may be actively kept up at a temperature varying from this point to 140° Fahr., according to the degree of exhaustion maintained and the state of inspissation of the extract. The condenser must be continuously supplied with cold water, which enters through the tube M at the bottom, while the hot water passes off from the top through the tube N.

It may be well to observe, that the preparation of extract of sarsaparilla by this process is attended with considerable difficulty, in consequence of the tendency of the liquor to froth up, and thus pass over into the receiver.

Spontaneous evaporation, has within the last few years been very successfully applied in the preparation of extracts. This process consists in the means for effecting evaporation at the ordinary temperature of the atmosphere. Practically, however, artificial heat to a certain extent is generally employed, and the process is still called one of spontaneous evaporation, if conducted at the temperature of a dry-

ing-room. The first specimens of extract prepared by this process were made by exposing the liquid in shallow vessels to the direct rays of the sun. Extracts of very good quality have been thus made from the expressed juices of some of our indigenous plants, such as hemlock, henbane, belladonna, dandelion, &c., by merely exposing them, in large shallow pans, in the open air, during fine warm summer weather. But the climate of this country is too uncertain to admit of the general adoption of this means of inspissation, and numerous contrivances have therefore been resorted to for promoting evaporation at low temperatures by artificial means.

The evaporation of water and other liquids at temperatures below their boiling-points is due to the diffusion of their vapours into the superincumbent atmosphere. All gases and vapours have a tendency to diffuse themselves into—that is, to become intimately mixed with—other gases or vapours that they have access to. In the case of water, it is found that the extent to which the diffusion of its vapour will take place in air, is the same as would occur at a like temperature into a vacuum of the same area. The amount depends on the temperature of the air or vacuum space. Thus, the quantity of vapour of water that a given volume of air is capable of holding in diffusion at 60° Fahr. is double what it would be at 40°.

In effecting spontaneous evaporation, therefore, the rapidity with which the process is conducted will depend,—1. *On the previous state of dryness of the air*; for as air can only hold a certain limited quantity of vapour of water in suspension, whatever it may already contain will so far limit its power of inducing diffusion; and if it be already saturated, no further diffusion can take place into it. 2. *On the temperature of the air*; for the higher the temperature, other circumstances being equal, the greater the amount of vapour it is capable of taking up. 3. *On the removal of the superincumbent air as soon as diffusion has taken place into it*; for the speed with which the vapour rises is greatly retarded as the air becomes partly saturated.

The most effectual means for promoting spontaneous evaporation consists in causing a current of warm dry air to pass over the surface of the evaporating liquid. In fact, an efficient drying-closet, or drying-room, constitutes the essential part of the required arrangement; but in the preparation of extracts it is much more important to adopt *all* practicable means for expediting the process, than it would be in the ordinary use of a drying-closet for the desiccation of plants or drugs.

The principal obstacle to the application of spontaneous evaporation in the preparation of extracts arises from the difficulty there is in insuring the speedy evaporation by this means of large quantities of liquid in all states of the weather. Most of the plans hitherto recommended have been applicable only to operations on the small scale; indeed, the process has hitherto been applied principally to the preparation of small quantities of some particular extracts, which are supposed to be much injured by the application of heat. Some of the specimens thus prepared, however, have been of very superior quality, possessing the peculiar flavour and aroma of the plant, I think, in a higher degree than is usually the case with those prepared by the vacuum process. It is a question, therefore, deserving careful investigation, whether it is not possible to construct such a drying-closet as shall insure the uniform, speedy, and economical evaporation of large quantities of liquid at the temperature contemplated in this process.

I have found that a drying-loft at the top of the house, with louver boarding on two opposite sides of it, admitting a current of air to pass through, and one of Arnott's stoves fixed in the centre of the room, to maintain a constant temperature of about 80°, afforded means for evaporating many gallons of liquid in the course of a day in favourable weather, if the liquor be exposed in very shallow vessels. When the weather is unfavourable, however, this arrangement does not answer well.

Drying-closet.—A good, efficient drying-closet is an important desideratum to the pharmaceutical chemist. Not only is it required for drying herbs, flowers, &c., so as to fit them for preservation, but in many operations of the shop and laboratory, and in all those of the powdering-room, its services are called into requisition.

In constructing a drying-closet, the method of heating it should be a primary consideration. It ought always to be ready for use, however trifling the purpose may be for which it is required. It is therefore desirable that it should not be heated by a fire appropriated expressly to that purpose, but should borrow heat from some source where a continual supply is necessarily maintained. The expense of an exclusive fire would frequently cause the closet to be left inoperative; or even if put into operation, the fire may be neglected from forgetfulness, and the closet thus rendered inefficient.

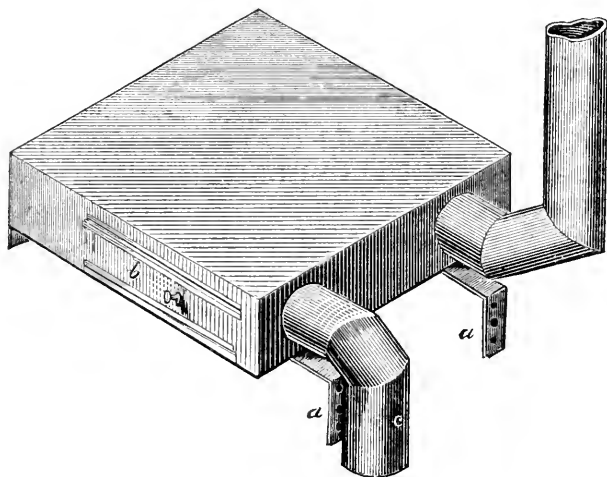
From these considerations, and principally from those of economy, it has long been attempted to attach the drying-closet to a fire-place

in constant use, the spare heat of which may be thus appropriated. It is sometimes attached to the *Beindorf apparatus*, but this is not always found to be a convenient arrangement, at least in the way in which it is usually effected, which consists in carrying the flue of the furnace underneath the floor and then through the closet. The heat thus derived from this furnace is insufficient for the purpose required, and the method of applying it causes an obstruction to the draught of the furnace, especially on first lighting the fire.

I have found it a better plan to transfer the drying-closet to the kitchen, by which means the space it would otherwise occupy in the laboratory is saved, and the use of a constant and powerful fire is obtained, without additional expense or exclusive attention.

The closet is heated by means of a box, made of tin-plate or sheet-iron (fig. 279), which is fixed within it, and communicates by the pipe

Fig. 279.

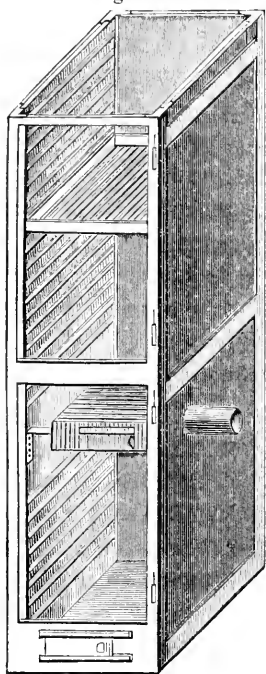


HEATING-BOX FOR MOHR'S DRYING-CLOSET.

c, with the flue that heats the boiler or oven of the range; or in the absence of these, the pipe may be made to terminate at the side or back of the fire-place, so that part of the hot air of the fire may pass through it into the box, and subsequently through the pipe *d* into the chimney. The heating-box is made with a flat surface, as represented in the drawing, so that any vessels may be placed upon it, and thus receive the strongest heat of the closet. The diameter of the box is about seven inches less than that of the closet, so that there is an intervening space of $3\frac{1}{2}$ inches on every side between the box and the

side-walls of the closet. The box rests on two iron bars, *a, a*, which are attached to the sides of the closet, the box itself being movable, so that it may at any time be taken out for the purpose of removing

Fig. 280.



MOHR'S DRYING-CLOSET.

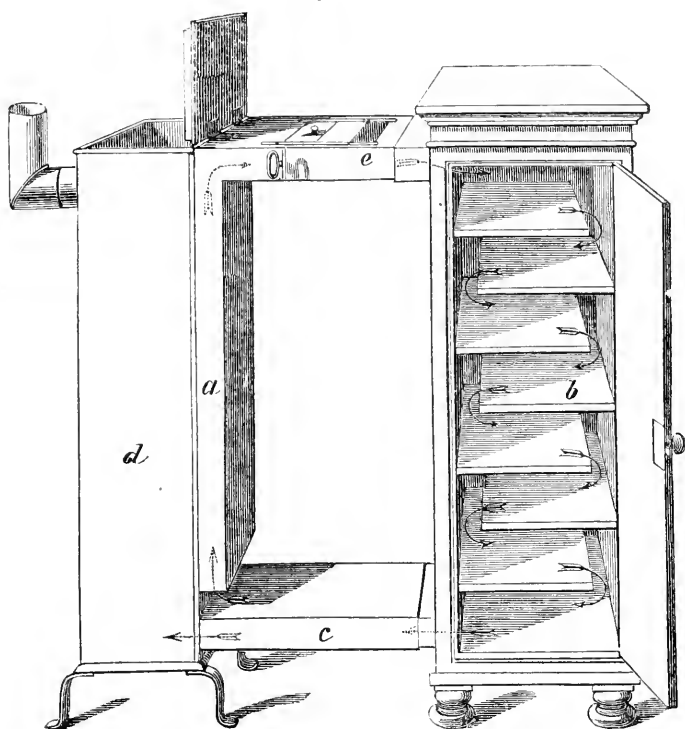
the soot that collects in it, through the door *b*. The closet may be made of wood, the crevices between the boards being closed by pasting paper over them. Laths are nailed against the sides of the closet, at a distance of four or five inches apart, as shown in fig. 280, to receive the trays on which the substances to be dried are placed. The trays are made by first forming a square frame the size of the closet, and about two inches deep, and thin laths or bars are then nailed across the bottom, at about half an inch distance from each other, leaving, however, an open space of about $2\frac{1}{2}$ inches at one end. A sheet of blotting-paper is put over these bars, and on this another sheet of paper containing the substance to be dried. The open space, over which the bars are not fixed, is left uncovered, so that the hot air in traversing the closet may pass up here; and in putting the trays into their places, they should be so placed that the openings shall be alternately on the right and on the left hand side, thus causing the current of air to pass in a serpentine direction over the surface of all the trays.

The following are the dimensions of a closet of the above description, which I have found from use to be generally convenient:—From side to side, and from front to back, it measures twenty-eight inches, while the height is $8\frac{1}{2}$ feet. It would perhaps be better to have it not quite so high as this, as the top trays are beyond the reach of the arm. The distance from the bottom of the closet to that of the heating-box, is three feet. The heating-box is $5\frac{1}{2}$ inches high, and its lateral dimensions are $21\frac{1}{2}$ inches in each direction. The flue-pipes are $4\frac{3}{4}$ inches in diameter. There are fifteen trays above the heating-box, and five below it. Fig. 281 represents the closet in perspective; it shows the heating-box and one of the trays in the upper part of the closet. One of the flues is seen passing out at the side,—

the other is not seen, as it enters on the opposite side of the closet. The doors and top are supposed to be removed, to show the interior of the closet. No express provision is made for the entrance or exit of air, as the crevices between the door and frame, and in other parts, are generally found to be sufficient for this purpose; but a few holes may be made in the bottom and top, if thought desirable. In practice it is found better to keep the temperature of the closet pretty high, by having few openings, than by rapid changes of the atmosphere to cause a reduction of the temperature.

The drying-closet attached to the *pharmaceutical stove*, described at page 125, is constructed on a principle which, I believe, would admit of successful application for the purpose here contemplated.

Fig. 281.



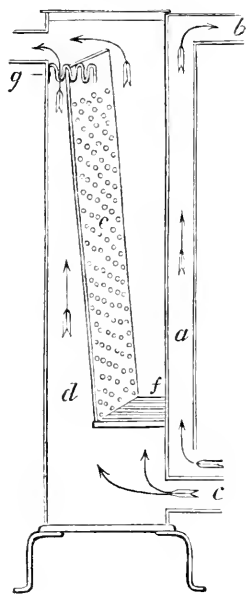
APPARATUS FOR SPONTANEOUS EVAPORATION.

I have constructed a small closet on this principle expressly for the preparation of extracts, with the view of trying its efficacy, and can strongly recommend its adoption on the large scale. Figs. 281 and 282, which represent the apparatus as I have used it, will serve to

explain all the essential features of the arrangement, but some modifications would perhaps be required in applying it on the large scale.

The closet (*b*, fig. 281) is furnished with shelves, fixed as shown in the drawing, and a door which fits closely when shut. Air enters the closet through the tube *a* *c*, and passing down over the shelves in the manner indicated by the arrows, it escapes through the tube *c* into the bottom of the stove (*d*).

Fig. 282.



SECTION OF STOVE.

A section of the stove is shown in fig. 282, from which its construction will be better understood. The grate (*f*) and the perforated iron plate (*e*) form the fire-place, which is supplied with gas-coke, or other suitable fuel, through the top, which opens as shown in fig. 281; and the combustion is supported by the air which is drawn from the closet through the tube *c*. The size of the fire-place is regulated by inclining the perforated plate (*e*) more or less, by means of a support (*g*) at the top, and a space (*d*) is left for a current of air to pass into the chimney.

When the stove is in operation, the air passes through *a*, in contact with the heated metal of the stove, and enters the top of the closet in a state best adapted for absorbing moisture. There is a sliding door in the tube *e*, (fig. 281,) by which air can be admitted there if required, and a valve for checking the current through *a*, by which means the

temperature of the air as it enters the closet can be regulated. The higher the temperature of the air, of course the more rapid will the evaporation be; and a heat of 100° does not appear to be too high in reference to its influence on the extract under operation. The air entering the closet at this temperature comes in contact with the liquid to be evaporated, which is placed on the shelves in shallow vessels. Diffusion of the vapour of water takes place into the heated air, and this is necessarily accompanied by a reduction of temperature: the air, therefore, becomes specifically heavier, in consequence of the moisture it has absorbed and its reduced heat; hence it tends downwards, whilst its place is supplied by fresh particles of warm and less saturated air from above. Each particle of air thus traverses the surface of all the trays containing the evaporating liquid, com-

mencing at the top in its most efficient state, and finally passing off at the bottom reduced in temperature and loaded with moisture. On entering the stove, part of the air contributes to the support of the combustion, and the remainder, now again heated by the fire, rapidly passes off through the chimney.

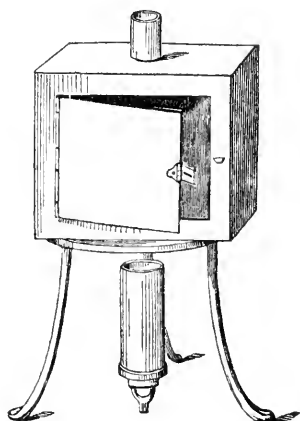
[Fig. 283 represents a portable drying-closet, which may be used in desiccating powders, lozenges, precipitates, or other substances. It consists of a double-sided tinned iron box, with an opening in front, which is closed by a door. The interior space is filled with water, which may be kept at any temperature up to 212° Fahr. The interior, or oven, has its sides arranged for supporting slides. The heat is applied by a gas-burner, as in the figure, or by any other lamp.—W. P.]

A blowing machine has sometimes been employed for sending a current of air through a closet used for spontaneous evaporation; but I have not found this method to be efficient unless it be accompanied by means for supplying heat. Every ounce of water evaporated, whatever the process adopted may be, absorbs as much heat as would be sufficient to raise the temperature of that water to 1212° Fahr. The reduction of temperature occasioned by spontaneous evaporation is, therefore, very great, and provision must be made to compensate for this reduction, if rapid evaporation be required. Accompanied with such provisions, however, a blowing-machine may be advantageously used. Fig. 284 represents a very efficient machine, by which a powerful blast of air is propelled. The cover (*a*) is removed, to show the construction of the fanners (*b*), to which very rapid motion is given by the accelerating wheels.

But, even under the most favourable circumstances, spontaneous evaporation will be a much slower process for the preparation of extracts, than any of those previously noticed, unless the extent of evaporating surface be greatly extended. The operator will, therefore, be inevitably disappointed in the result, if his provisions be not made on a very ample scale, a small room, rather than a closet, being required, where large quantities are operated upon.

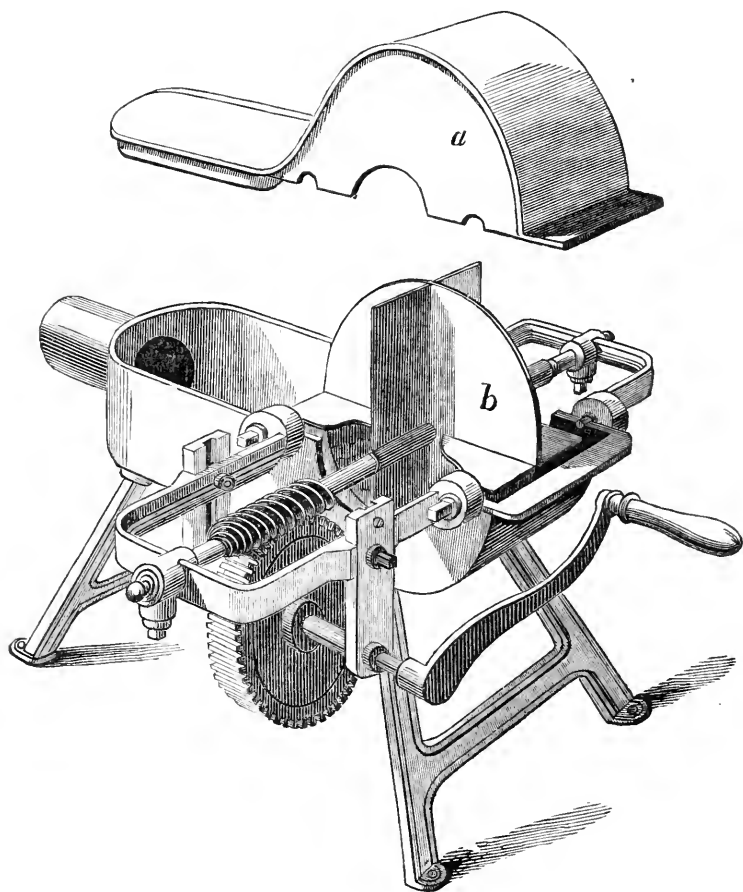
There is yet another point deserving of notice in connexion with

Fig. 283.



the preparation of extracts. Those who are much engaged in these manipulations frequently experience difficulty in providing efficient means for crushing the recent herbs, from the expressed juices of which some of the most active and valuable of the medicinal extracts

Fig. 284.



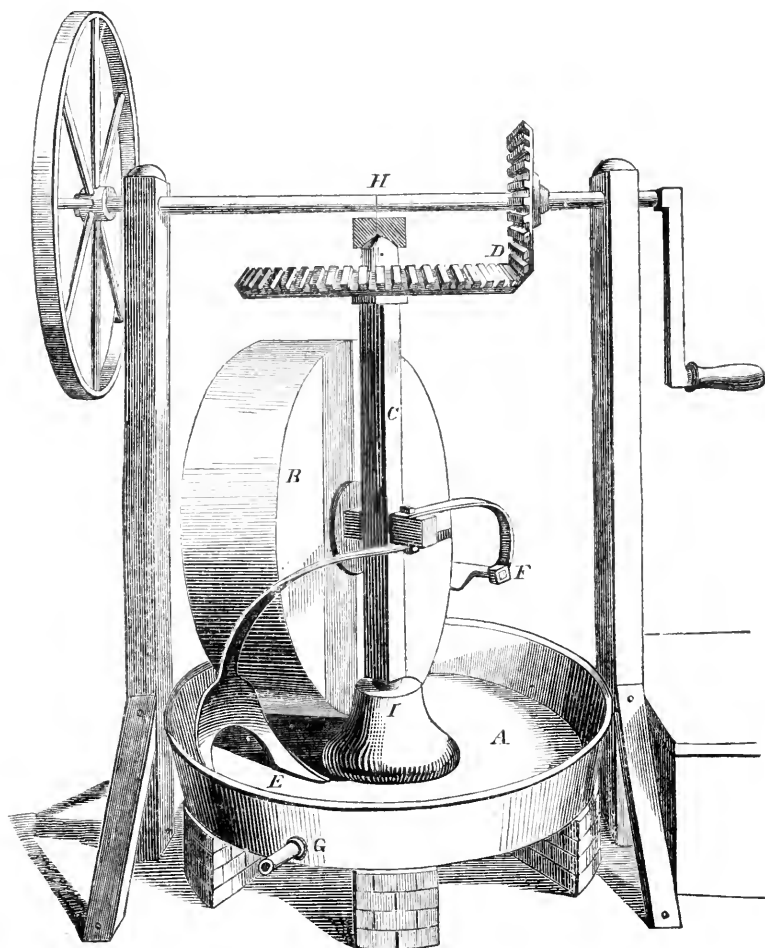
BLOWING MACHINE.

are made. This operation is sometimes performed with the pestle and mortar; but the time and labour expended in crushing a large quantity of herb in this way occasions a considerable increase in the duration of the process and the cost of the product. In making the extracts now under consideration, the herb ought to be gathered, crushed, and pressed, and the liquor evaporated to the proper con-

sistence, in one and the same day; and this can only be done where efficient means are provided for accelerating every step in the process.

The best apparatus for crushing herbs is that represented in fig. 285, which is commonly known as the *Pugging-mill*. It consists of the platform A, with raised sides, which may be made of thick cast-iron, and set on brick-work. On this a large stone runner (B), turn-

Fig. 285.



PUGGING-MILL.

ing on an axle fixed to the beam C, is trundled round by the winch and bevel wheel and pinion (D). The outer surface of the runner is not bevelled, but is at right angles with the lateral faces; therefore,

if trundled without control, it would move in a straight line, and, in being carried round the axis C, which works in two sockets at H and I, a peculiar grinding motion is maintained, which contributes greatly towards producing the effect required.

The substance to be crushed or ground is placed on the platform in the path of the runner, which passing over it, the weight of the stone, together with the friction occasioned by the particular motion alluded to, causes the required disintegration. In continuing this operation, the partly disintegrated substance will be dispersed on each side of the course of the stone, and this is again put into its proper position by the *plough* (E) which precedes the runner, while the *scraper* (F) is fixed behind to remove any portion of the substance that may adhere to the stone and obstruct its progress or action. Any juice that escapes during the process will run off through the pipe G.

[GENERAL HINTS ON THE CLASSIFICATION AND PREPARATION OF
EXTRACTS.

Extracts are classified according to the menstruum used in making them; hence there are *watery* or *aqueous*, *alcoholic*, *hydro-alcoholic*, *ethercal*, *vinous*, and *acetic* extracts. The reasons for using these menstrua have reference, chiefly, to the solubility of the principles to be extracted. In constructing a formula for the preparation of an extract, the operator should first acquaint himself with the nature of the principles contained in the drug, their solubility, their relations to heat and air, their volatility, &c., so that he may adopt the menstruum best calculated to remove the greatest amount of active matter, and control the evaporation, so that this may not be injured by heat, or lost by volatilization. For instance, in the extraction of *krameria*; by examining its composition, he will find that the root contains a peculiar tannin, soluble in cold water and alcohol; a large amount of inert apothegm or altered tannin, soluble in boiling water and alcohol, and nearly insoluble in cold water; a portion of starch and some other substances. Now, by applying cold water as the solvent, the starch and apothegm are avoided, (whilst either alcohol or boiling water would include them,) and a well-regulated heat during the concentration of the cold infusion, will yield an astringent soluble extract, but slightly changed by the operation.

Suppose the substance to be extracted is *valerian root*. In this case a complex volatile oil, a volatile acid, its most valuable constituent, bitter extractive having tonic properties, and a resin, are concerned, and should be found in the extract. It is self-evident, that

boiling in water and evaporation at 212° Fahr., will not be eligible: cold water will only partially remove them. Under these circumstances the root, in coarse powder, should be displaced, without previous maceration, with concentrated alcohol, until a pint of tincture is obtained for each pound of the root treated. This tincture will contain *nearly all* of the volatile and resinous principles, and should be suffered to evaporate, spontaneously, till it assumes a syrupy consistence. The residue of the valerian, impregnated with alcohol, is then displaced with weak alcohol (20° B.) until exhausted of bitterness, and the liquid evaporated to a similar syrupy consistence; the two soft extracts are then well mixed, and reduced to the proper consistence by a careful evaporation. In this treatment much of the inert gummy matter of the root is avoided, and all the active volatile ingredients are retained in the extract.

Chamomile, juniper, savin, buchu, and indeed every drug, the active principle of which is volatile, may be subjected to the same treatment when their extracts are wanted.

In the instance of jalap, the U. S. Pharmacopœia directs the powdered root to be exhausted by alcohol 835, to remove the resin; and then by cold water; in each case by displacement. The tincture is distilled, and the infusion evaporated, till each is reduced to a syrupy state, when they are thoroughly mixed, and the extract completed by evaporation in a water-bath. The matter extracted by water, though inactive *per se*, yet by intimate mixture with the resinous particles, it modifies the violence of their action, and renders them more readily diffusible in the liquids of the stomach.

In certain cases extracts are made with strong alcohol alone, as in that of nux vomica, in which substance the salts of strychnia and brucia are associated with a large quantity of inert matter, soluble in water. The same menstruum is employed when resins are to be isolated. In some instances a simple alcoholic extract is all that is desirable, as in the Edinburgh process for jalap resin; but when this resin is to be obtained pure, the syrupy alcoholic extract is thrown into water, which dissolves some colouring matter, and uncrystallizable sugar, and leaves the coloured resin, which is friable and pulverizable when dry, and which may be deprived of colour entirely, by the process detailed at page 212, by means of animal carbon.

There are some drugs which contain so large a proportion of volatile oil and resin, that these may be extracted as fluid or semifluid oleoresins analogous to copaiba, and highly eligible for medicinal use, owing to their uniform strength and consistence. Cubebs, black pepper, cap-

sicum, ginger, cardamom seeds, pellitory, malefern, and wormseed, are among these substances. The menstruum employed is ether. The drugs, in moderately fine powder, are compressed in a displacer, (fig. 270,) and treated directly with the ether, until as much tincture is obtained as equals twice the weight of the substance treated. The apparatus of Dr. Mohr, page 263, will be very economical for this use, but it is too complex to be within reach of every one who may desire to make these preparations. When cubebs are thus treated the ethereal tincture is introduced into a retort, and by means of a water-bath kept at 120° Fahr.; seven-eighths of the ether is distilled off, observing to introduce some fragments of glass into the retort, to facilitate the liberation of the ethereal vapour. The fluid residue is then placed in an evaporating capsule, and left exposed until the remains of the ether passes off. Cubebs yield about fifteen per cent. of a fluid oleo-resinous extract by this process. In the case of cardamoms, the extract consists of volatile oil, fixed oil, and a little resin, and is so entirely fluid and permanent that it may be used with great propriety in pharmacy, for aromatizing powders in prescriptions. The presence of the fixed oil tends to preserve the volatile oil, which, when pure, soon changes by exposure to the air.

Besides these fluid ethereal extracts, several drugs, as cantharides and mezereum, yield to this liquid their active principles, which are obtained as soft and active extracts, by evaporation.

Vinous extracts are rarely made, that of colchicum root being the only one in use here.

Acetic extracts are usually prepared from drugs containing alkaloids,—as colchicum, opium, &c.—on the ground that the acetic salts of these alkaloids are more soluble than those naturally existing; or, that the acid is a corrective to some noxious property of the drug. No particular directions are necessary in their preparation, except that the amount of menstruum should bear a proper proportion to that of the drug, else the acetic acid, which is less volatile than water, will be contained in too large a quantity in the extract.

Consistence of Extracts.—The consistence of extracts varies much, owing to the nature of their ingredients. There are but two degrees of consistence recognised in the Pharmacopœias; that suitable for making pills, and perfectly dry or pulverizable. When uncrystallizable sugar, or certain salts, enter into the composition of extracts, they are apt to be deliquescent,—as gentian and colchicum; on the contrary, if much tannin exists in them, they have a strong tendency

to dry and crumble into grains, as kino, extract of nutgalls, or rhatany. In the last case, it is better at once to reduce them to dryness.

In some instances, two forms of an extract are kept, so as to be used in pills or powders, as the dispenser may desire. Extracts of narcotic plants, made from juices, have a tendency to become hard, tough, and difficult to incorporate with other substances. This is more especially true of those that contain the albumen and green colouring matter. When the last two substances are removed, these extracts will keep their consistence much better, and the chloride of potassium, and other salts which often exist to a considerable extent in them, are less liable to crystallize on their surfaces.

It is one of the most difficult problems of practical pharmacy, to keep these preparations of a uniform consistence, when in course of being sold or dispensed. Where their consumption is limited, the jars from which they are used should be small, kept well covered with tin-foil or waxed paper, and placed within the ordinary shop jar. The jars should be well glazed, and incapable of absorbing moisture from the extracts, else these will contract and harden, although they may be well covered above. It has been proposed to introduce *glycerin* into extracts, to prevent a tendency to harden; I am not aware that it has ever been tried, and its therapeutical properties are not sufficiently well understood to justify a resort to such means.

Fluid Extracts.—There is another kind of fluid extracts, besides those which have been described as resulting from the action of ether on oleo-resinous drugs. The process for making them is the same as for solid extracts, up to a certain point in the concentration of the solution, when, either alcohol or sugar is added, with a view to preserve the vegetable matter from decomposition. There are two strengths of these preparations: those in which a fluid-ounce represents a weighed ounce of the drug, as the fluid extracts of rhubarb, senna, and taraxacum; and those in which that quantity represents but half an ounce of the medicinal substance. The alcoholic fluid extracts, as those of valerian and buchu, besides being much more concentrated than the tinctures, possess the advantage over the latter, of presenting the same amount of activity, associated with much less alcohol.—W. P.]

CHAPTER XI.

DISTILLATION. THE DISTILLATION OF OIL OF VITRIOL, OF THE ESSENTIAL OILS, OF DISTILLED WATERS, AND THE RECTIFICATION OF ETHER.

DISTILLATION.

THE separation of more volatile liquids from those that are less volatile, is effected by the process of *distillation*. This process involves, first, the volatilization of the distilled product by the application of heat, and, secondly, its condensation in a separate part of the apparatus.

[Distillation differs from evaporation only in the object to be gained, and the apparatus required in its execution. An ounce weight of steam at 212° Fahr. when brought in contact with a condensing surface, yields an ounce weight of water, and gives out sufficient heat to raise the temperature of nine ounces of water from 70° to 212° . As it is desirable to keep the condensing surface below 110° Fahr. for aqueous liquids, an ounce weight of steam would therefore require twenty-five ounces of water at 70° F. to condense it.

The greater the difference of temperature between the vapours and the condensing surface, the more rapidly is condensation effected. According to Dr. Ure, (Dict. Arts and Manufactures,) ten square feet of thin copper, cooled by water, will condense three pounds of steam per minute, if there be a difference of 90° in their temperature, or just three times the amount that the same extent of surface will vaporize by the application of direct heat. This fact is important in the construction of apparatus for distillation, as there should be a proper relation between the heating and condensing surfaces.—W. P.]

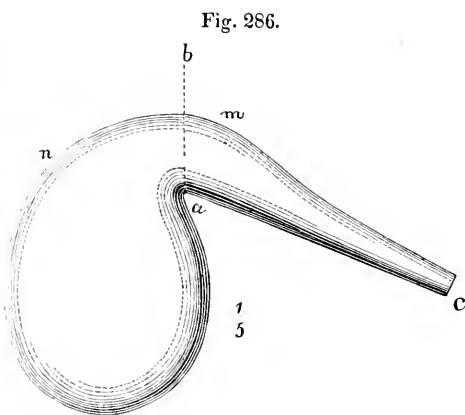
The methods of effecting distillation on the large scale, and by the application of steam, have already been explained in connexion with the description of stills and steam apparatus. We have now more

particularly to treat of distillation as conducted in retorts, and other apparatus of a similar kind.

[Retorts are constructed of glass, porcelain, earthenware, iron, lead, &c., according to the purpose for which they are designed. The glass retort, owing to the great advantages derivable from its transparency, is always used when practicable. Retorts are either plain or tubulated, and the employment of the one or the other form will depend much on the nature of the operation to be performed.—W. P.]

In the first place, then, the proper form of the distillatory vessel should be considered. In the distillation of liquids which boil only at a high temperature, the shape of the retort has considerable influence on the result, as much of the vapour often condenses in the top and neck of the retort, and, if the form of this part be defective, the condensed liquor runs back into the body of the vessel.

Fig. 286 represents a well-formed retort. Holding it so that the axis of its body shall be vertical, and imagining a perpendicular line from the commencement of the neck at *a* in the direction *ab*, the angle *b a c*, should be an obtuse angle, and the line *a c* should be straight. The line *a b* should cut the top of the retort at its highest point, or, at least, the top ought not to rise from this point in the direction of the beak. The diameter of the neck should contract rather suddenly at *m*, and afterwards gradually to the end, so as to admit of its being introduced some way into the mouth of the receiver or condenser.



WELL-FORMED RETORT.

The bottom of the retort should be spherical, and the thickness of the glass as equal as possible in this part, and it should be free from air bubbles or other imperfections. It is also desirable that the glass should not be thick in this part, and that it should not be too thin at *n*, which is usually the weakest part of the vessel, from its having been drawn out here in bending it to give it the required form. From this the name *retort* is derived (from *retorqueo*, to bend back).

Figs. 287 and 288 represent two badly-formed retorts. In each of these the highest point is beyond the line *a*, so that the liquid which

Fig. 287.

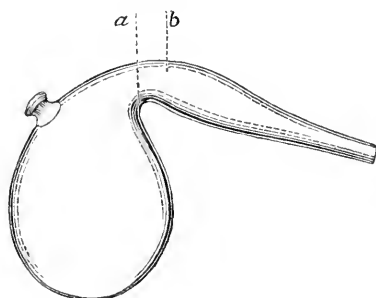
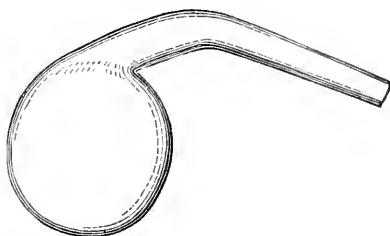


Fig. 288.



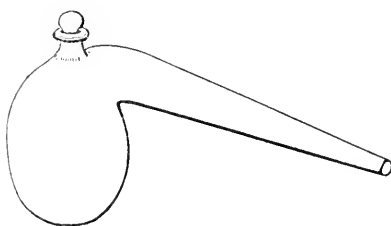
BADLY-FORMED RETORTS.

condenses in the space between *a* and *b* will run back into the body of the retort.

These retorts, however, are not useless. They should not be selected for the distillation of the mineral acids, or of liquids generally which have a high boiling point, and are at the same time easily condensed; but they may be used without disadvantage in the distillation of some easily volatilized substances.

[Tubulated retorts are more apt to be illy formed than the plain, and their value is considerably influenced by the position of the tubulure, with reference to the retort. A line drawn through the axis of the stopper should strike the centre of the bowl of the retort, as at fig. 289, so that a funnel, placed in the tubulure, will empty its contents directly into the retort body, without soiling the neck. The tubulure should

Fig. 289.

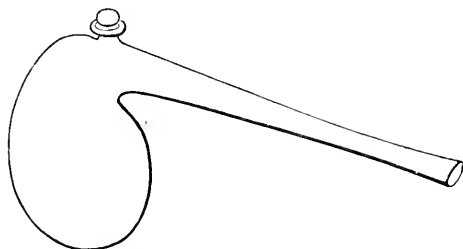


WELL-FORMED TUBULATED RETORT.

be on the dome of the retort, near its apex, on the side opposite from the neck, so that any substance adhering to the sides of the tubulure or the stopper, shall be carried into the retort by the vapour that first condenses on that part of the apparatus. The surface of the neck of the retort should be of sufficient extent to effect the condensation of all the vapour generated, when it is preferred to apply the refrigeration

to that part. The neck should always decrease in size to the termination, so that in fitting a cork joint, the ring may slip over the end, and become tighter by being forced up.

Fig. 290 represents a badly-formed tubulated retort.



BADLY-FORMED TUBULATED RETORT.

Porcelain and earthenware retorts are only used where the process is conducted at high temperatures, as in the distillation of mercury, phosphorus, &c. Iron retorts are used for destructive distillation, or for the generation of ammoniacal and other gases requiring a strong heat. Lead retorts are chiefly employed in making hydrofluoric acid.

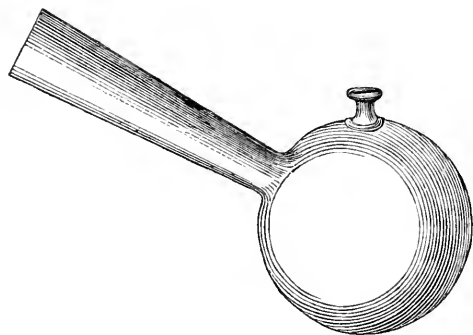
Receivers are either plain, tubulated, or quilled. Sometimes they are quilled without being tubulated.—W. P.]

The receiver is a wide-necked globular glass vessel, the neck of which is made to widen gradually outwards, so that it may fit on to the tapering beak of the retort.

Its proper form is indicated in fig. 291. When tubulated, the opening should be in that part of the globe that will be uppermost when the neck is attached to the retort, as shown in the drawing.

The glass of which these vessels, and especially retorts, are made, ought not to be very thick, as in this case they are more liable to crack when exposed to sudden alterations of temperature. Thin glass is much less likely to break from these causes, but if it be very thin, the vessels will be deficient in strength, and will be liable to be broken by the slightest tap against any hard substance. Of the two evils, the latter is perhaps that which ought most to be avoided, as it will be found that a much greater number of these vessels are broken in cleaning them and in

Fig. 291.

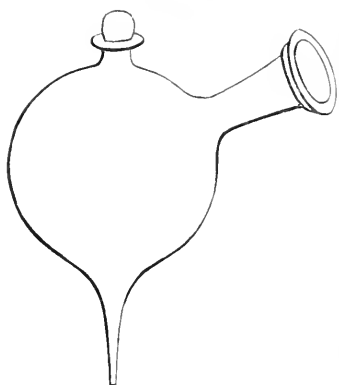


TUBULATED RECEIVER.

other manipulations, from want of sufficient strength, than from any other cause.

[The quilled receiver, fig. 292, is used when it is desirable that the quantity of the distillate should be accurately known, as in the process for hydrocyanic acid. The quill tube is inserted into a graduated bottle, through a cork joint. This kind of receiver is less used since the employment of Liebig's condenser, which also admits of adjustment to a graduated bottle. —W. P.]

Fig. 292.



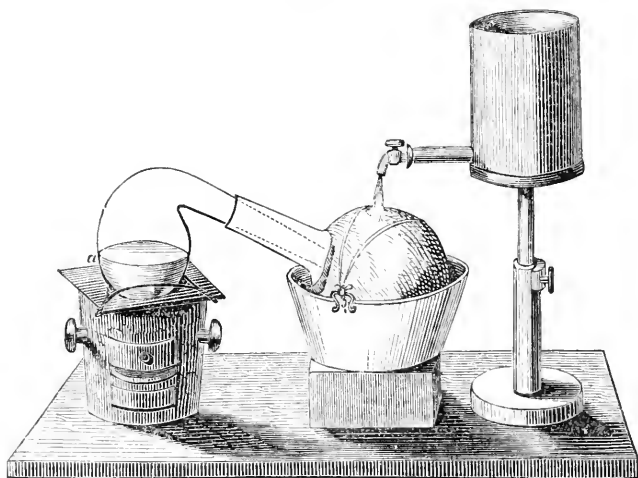
QUILLED RECEIVER.

The method of shortening the necks of retorts and receivers will be described in another place.

There are several ways of applying heat to retorts and distillatory vessels, either over the naked fire, or through the medium of sand or some liquid.

The usual method of exposing retorts over the naked fire, is to place them on an iron triangle, or on a piece of wire-gauze. When the triangle alone is used, the vessel placed upon it touches only at three points,

Fig. 293.



PROCESS OF DISTILLATION.

and there is often great danger of its breaking from the pressure at these points.

A much safer method of operating consists in placing a piece of strong wire-gauze over the triangle, previously giving to the former a concave surface adapting it for the reception of the retort, which, when placed here, receives more uniform support and protection from mechanical injuries. The wire-gauze also promotes a more equal distribution of the heat, and to a certain extent protects the vessel from the action of the lambent flame of the fire. The bottom of the retort, however, should not, in any case, be so near to the fire as to be within reach of the flame, for this would be very likely to cause a fracture.

Charcoal is the only fuel that should be used in these operations. Wood, coal, or peat, would cause the deposition of soot, which would be objectionable, and, moreover, these substances burn with a lambent flame, which would render the process very unsafe.

Fig. 293, represents the entire arrangement of apparatus for conducting the process of distillation in this way. In this instance, the retort is supported by a triangle, placed over the wire-gauze.

Fig. 294, represents another arrangement for conducting the same

Fig. 294.

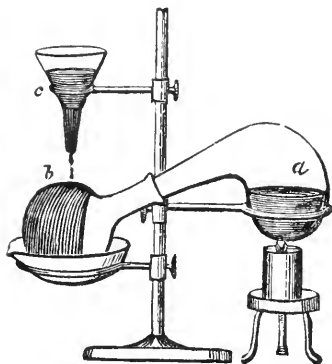
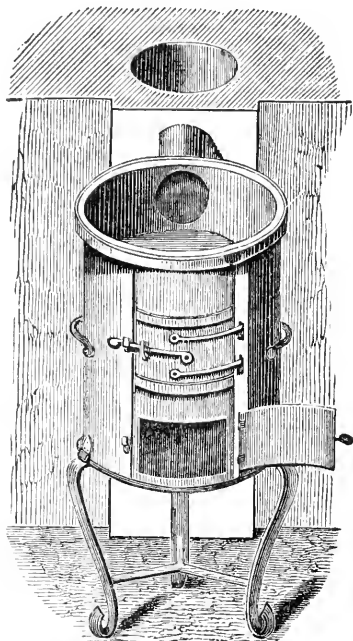


Fig. 295.



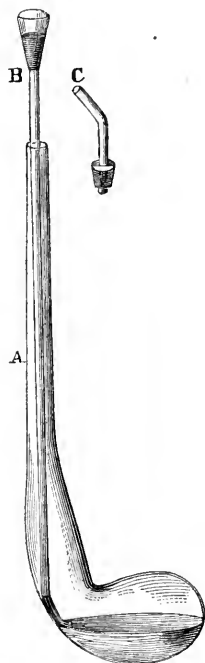
process on a smaller scale, a spirit-lamp being substituted for the furnace.

Liquid baths are seldom used for heating retorts, unless it be in the distillation of ether, or other very volatile liquids, in which cases a simple hot-water-bath may be employed. In the distillation of spirituous liquors, a concentrated solution of chloride of calcium, or chloride of potassium, salts which often result as secondary products from many processes, forms a good medium through which to convey the heat.

The retort should not be placed immediately on the bottom of the vessel containing these liquids, but on some kind of stand or support which shall admit of the free circulation of the liquid beneath it. When water alone is used as the bath, the retort may be placed on a wisp of straw, which will form a good bed for it.

During the process of distillation, the retort becoming lighter from the loss of liquid which has distilled over, sometimes floats in the bath, and thus rising from its bed, or stand, is liable to cause a disarrangement of the connexions of the apparatus, or even to occasion

Fig. 296.



METHOD OF CHARGING A PLAIN RETORT.

Fig. 297.



RETORT FUNNEL.

a fracture in the neck of the receiver. These evils may be avoided by tying down the retort with a piece of flexible copper wire.

The most convenient kind of bath for conveying heat to the retort, is the sand-bath. This should consist of coarse sand, the grains of which are clean and of equal size, having been freed from dirt, dust,

and stones, by washing and passing it through sieves. A cast-iron pot will form a suitable vessel for containing the sand, and the furnace, fig. 295, into the top of which the sand-bath may be fitted, will afford the required heat.

The retort should be charged previously to its being put into the sand-bath. Salts and powders are introduced by means of a long paper tube, as shown in fig. 296, and liquids are poured in through a funnel of a peculiar form (fig. 297), intended for this particular purpose. The ingredients may be thus introduced without any part of them adhering to, or even being allowed to come in contact with the neck of the retort.

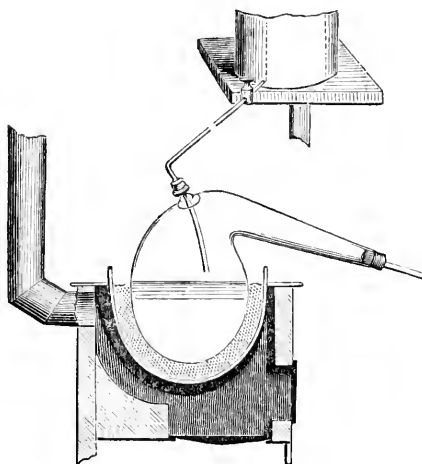
The retort being thus charged, is, in the next place, inserted in the sand-bath. The sand is removed from the iron pot, with the exception of a layer, about two inches in thickness, at the bottom, on which the retort is placed, and the surrounding space is then filled up with sand so as to form a stratum of equal thickness on all sides. This part of the arrangement is shown in fig. 298, which represents a section of the furnace, sand-bath, and retort.

The receiver is now attached to the neck of the retort. When a receiver is used without any intermediate condenser, it should be placed in a large earthenware basin, or in a shallow tub, in which the cold water may be applied to it. The

receiver should rest on a cloth or wisp of straw, and should be secured in its place with string or wire to prevent its floating as the water used for cooling it increases in quantity.

In most cases it will be found desirable to use a tubulated receiver, so as to allow any uncondensable vapours to escape through a bent tube attached to the tubulure. If a plain receiver be used, the connexion between the beak of the retort and the mouth of the receiver must be such as to admit of the escape of air or gases here, for in all cases the contained air of the vessels will undergo expansion on

Fig. 298.



the application of heat, and the pressure which would be thus produced, if no provision were made for its escape, would probably cause a fracture in the weaker parts of the retort. In the distillation of nitric acid, it is customary to use a plain receiver, merely inserting the neck of the retort loosely into it, and taking care that it pass some way into the body of the receiver. In most other cases it is preferable to make a close connexion at the mouth of the receiver, and to allow uncondensed gases to escape at the tubulure.

The connexion at the mouth of the receiver may be made in several different ways, but some soft substance should always be interposed between the retort and receiver, otherwise a fracture would be very likely to take place, if the two unyielding surfaces be brought into contact. A piece of folded paper is generally used as the interposed substance; and when this has been fixed in its place, some luting may be applied to the juncture on the outside, so as to render it air-tight. A strip of sheet India-rubber is sometimes substituted for paper, and answers the purpose well, as it is less easily acted upon by chemical agents than paper is, and, moreover, it renders the connexion air-tight without the use of luting. It will be obvious, however, that in the distillation of ether and essential oils, the use of caoutchouc would be inappropriate.

The top of the receiver is covered with a cloth, and cold water is allowed to fall on to this in a continuous stream, as shown in figs. 293 and 294.

There are some cases in which this method of effecting the condensation of distilled products will be found to be the best, as, for instance, in the distillation of liquids which are easily condensable, and in collecting which it is desirable to avoid any loss of the product from adhesion to the condenser, or any contact with organic substances, such as would be used in making the connexions of more complicated apparatus.

In most cases, however, in which substances are distilled from a retort, this arrangement would be subject to several objections. It would often be difficult to effect the condensation completely in this way, and sometimes the receiver, becoming much more heated in one part than another, may crack from the application of cold water. Then again, the distilled product could not be removed from time to time during the progress of the operation, but on the contrary, would be constantly exposed during this time to the hot vapours contained in the upper part of the receiver.

On account of these and other objections, apparatus designed expressly for effecting condensation are now commonly employed.

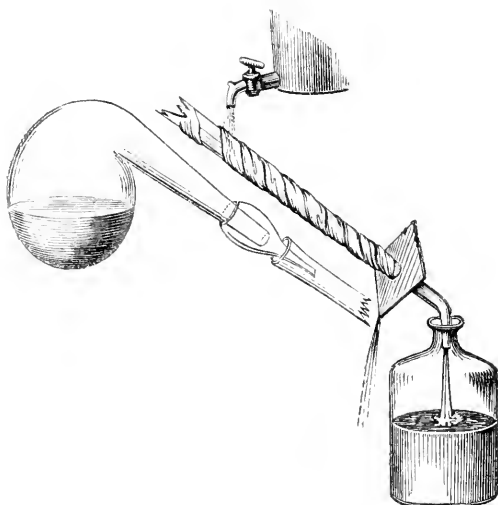
The most simple of these consists in lengthening the neck of the retort by interposing a tube between it and the receiver, and applying cold water to this tube by any suitable means. It may sometimes be found difficult, in the absence of apparatus made for the purpose, to find a tube one end of which will be large enough to receive the beak of the retort, while the other end is small enough to be inserted into the receiver. The apparatus called an *adapter* (fig. 299) is in-

Fig. 299.



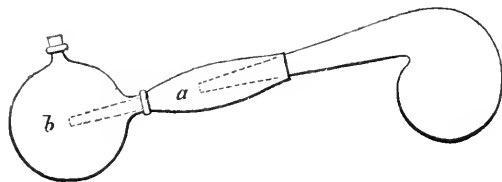
AN ADAPTER.

Fig. 300.



tended to be used in such cases. Figs. 300 and 301 represent arrangements in which the adapter is applied for connecting the retort and receiver.

Fig. 301.



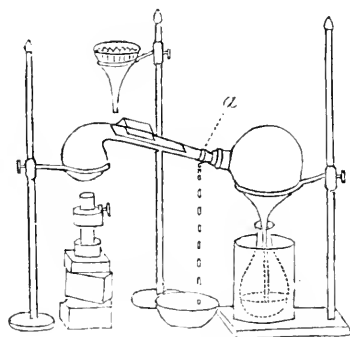
RETORT WITH RECEIVER AND ADAPTER.

In the absence of an adapter, a connecting piece may be made out of a phial of appropriate size, by cutting off the bottom and the rim of the neck. The method of cutting glass vessels of this kind will be described hereafter.

At the lower end of the condensing tube a piece of card is fixed, as shown in fig. 300, so as to prevent the water which is applied to the tube from running into the vessel in which the condensed liquor is collected. A strip of cloth is bound round the condensing tube, and a stream of cold water allowed to run over this, as shown in the drawing.

[Fig. 302 represents a mode of refrigerating, by applying the water to the neck of the retort, instead of to the adapter. An oblong

Fig. 302.

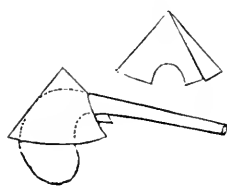


APPARATUS FOR DISTILLATION.

piece of thick lint, or loose cotton cloth, is laid on the neck, so as to cover one half of it, as in the figure; or what is better, a wide piece of the same material, previously moistened, is made to envelope the neck completely, and is kept in place by a loose tying of thread. After the joint is luted and the lint applied, a piece of tow or cotton should be wrapped around the neck of the retort, at *a*, to conduct off the descending water into the dish below. The refrigerating fluid should impinge

on the highest part of the lint, which will distribute it over the surface of the glass.

Fig. 303.



CAPPED RETORT.

In the distillation of small quantities of substances having high boiling-points, and which condense on the sides and dome of the retort, before the vapour can reach the neck, Faraday recommends the use of a conical cap of paste-board, as at fig. 303, which prevents the refrigerating effect of currents of cold air, and keeps in the heat.—W. P.]

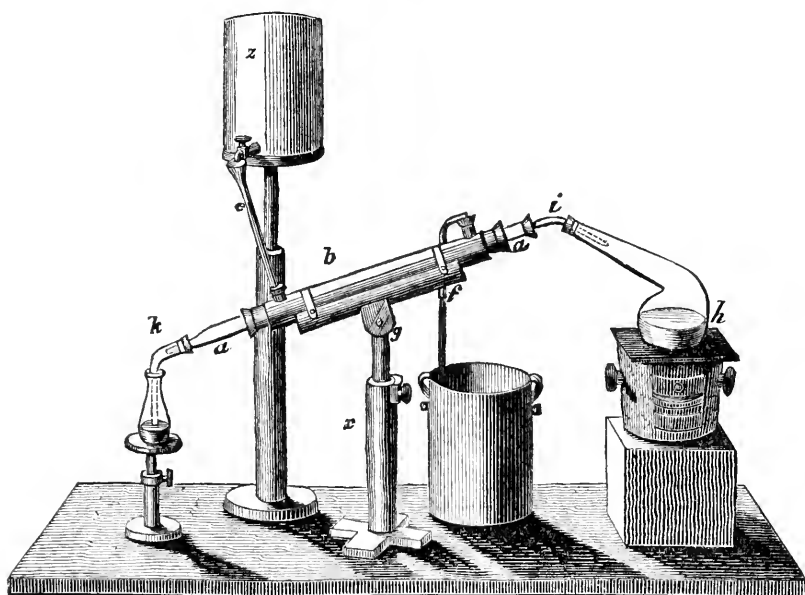
A more complete and efficient condenser is formed by causing the tube conveying the vapour to pass through another tube, the diameter of which is such as to leave a space between the two, through which a stream of water may be made to run. This kind of condenser, with the entire arrangement for conducting the process of distillation, is represented in fig. 304.

The glass tube (*a a*) is surrounded by a copper or brass tube (*b*), through the two ends of which the former is tightly inserted by means

ARRANGEMENTS FOR DISTILLATION.

of perforated corks. This rests on a wooden stand (*x*), which admits of its being raised or lowered or turned in any direction.

Fig. 304.



APPARATUS FOR DISTILLATION.

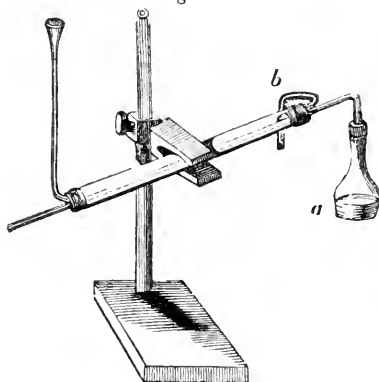
The retort (*h*) is placed over a charcoal fire, its neck being elevated as represented, and the beak connected with the condenser by means of a small tube (*i*), which is bent so as to form an obtuse angle, and which extends some distance into the neck of the retort. This arrangement, originally suggested by Liebig, offers advantages in certain cases, inasmuch as none but the most volatile parts are distilled, and nothing can be mechanically carried over by spirting. The neck of the retort is surrounded by dry paper, wrapped round several times, so as to prevent condensation from taking place here to too great an extent.

In the distillation of less volatile liquids, or those in reference to which there is no danger of any portion being carried over by spirting, the neck of the retort may be inclined in the usual way, in which case the tube (*i*) should not be bent, or may be dispensed with altogether, the beak of the retort being inserted into the end of the condenser.

The water used for the purpose of condensation, flows from a copper or tin vessel (*z*) through a stop-cock, by which the current is regulated, and is conveyed by the pipe *e* to the space between the

tubes *a* and *b*, through which it runs in a continuous current, and finally escapes at *f* into a vessel placed for its reception.

Fig. 305.



The distilled product is conveyed through the bent tube (*k*) into a receiver.

This method of effecting condensation is quite efficient, and is very convenient.

Fig. 305 represents a similar arrangement on a smaller scale, in which all the tubes are of glass.

[Liebig's condenser, as the apparatus (fig. 304) is called, may be constructed entirely of tinned iron, if for the condensation of neutral liquids, as alcohol ether, volatile oils, &c., and the metal condenses more rapidly than glass. When glass is used for the inner tube, the outer one may be constructed of tinned iron. It is better to have the funnel tube attached to the superior end of the condenser, and conducted along its upper surface to the inferior end, as then it need not project much above the tube, and is more conveniently handled and kept clean. The tube for the escape of the warm water should enter below, and pass around the condensing tube nearly to the top. In fig. 304, both of these tubes are movable and pass through corks, which possesses some advantages.]

Various arrangements for the application of heat from gas, and other lamps, will be found at page 94, in the chapter on the SOURCES AND MANAGEMENT OF HEAT.—W. P.]

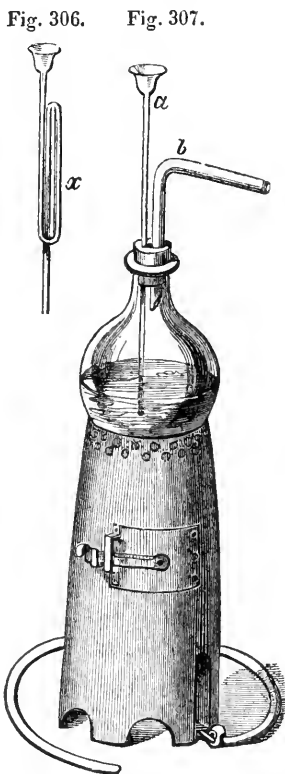
A *flask and bent tube* may often be substituted for the retort with advantage. They form a more convenient and economical arrangement, and may be applied without objection in most processes of the kind now under consideration.

The *flame of a gas-lamp* may also be advantageously substituted for the charcoal fire. It is much more manageable as a source of heat, and involves less trouble.

Fig. 307 represents the gas-furnace with a flask and bent tube, arranged for the process of distillation. The flask used for this purpose should be rather wide in the mouth, so as to receive a cork through which two tubes may be passed, as shown in the drawing. The diameter of the mouth should be from one inch and a half to one inch and three quarters.

It is sometimes desirable to have the neck of the flask rather longer than it is represented in fig. 307, and it may be extended to the length indicated in fig. 308. The tube-funnel (*a*, fig. 307) is intended for the introduction of fresh liquid into the flask during the progress of the distillation. Its lower extremity being immersed in the liquid, none of the vapour can escape through this tube. In cases where this arrangement cannot be conveniently adopted, the safety-tube (fig. 306) may be substituted for that shown in fig. 307. This tube, being bent in the manner represented, retains a portion of liquid in the part *x*, which prevents the escape of vapour from the interior of the flask. Its lower extremity should extend only a little below the cork.

The *sand-bath* (fig. 309) is sometimes used with the larger sized gas-furnace, where it is desired to equalize the heat applied, or to render glass vessels less liable to fracture. The use of the sand-bath, however, is not unobjectionable in processes in which it is necessary carefully to regulate the heat, for if the sand acquires a temperature higher than is desirable, it retains it for some time after the flame of the lamp has been lowered.



GAS-FURNACE AND FLASK FOR DISTILLATION.



Fig. 308.

FLASK.



Fig. 309.

SAND-BATH.

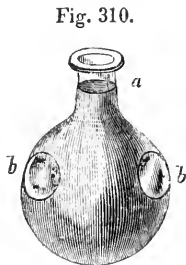


Fig. 310.

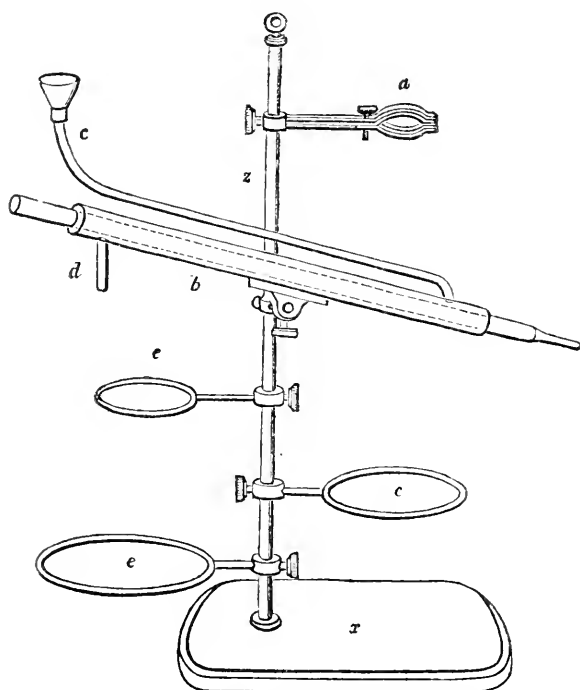
FLASK COATED WITH COPPER.

The use of flasks coated on the outside with copper presents many

advantages. I have used flasks of this kind for several years, having met with them, in the first instance, at the *Exposition of Works of Art* at Paris in 1844, and consider them to be of great value in the laboratory. The copper affords protection to the glass, while, from its good conducting power, it insures a more equal distribution of the heat to all parts of the vessel. Fig. 310 represents one of these flasks, covered with copper to the mark *a* on the neck. There are three circular spaces left uncovered, two of which are shown in the drawing at *b b*, so that the contents of the vessel can always be seen by the operator. The manner of coating these flasks will be described hereafter.

The *condenser* used in this arrangement is supported on a retort-stand, as shown in fig. 311, having freedom of motion in every direc-

Fig. 311.



RETORT-STAND WITH GAY-LUSSAC HOLDER, LIEBIG'S CONDENSER AND RINGS.

tion. The retort-stand consists of a cast-iron foot (*x*), in which is fixed a round solid rod of iron (*z*). The rings *e, e, e*, the Gay-Lussac holder (*a*), and the Liebig's condenser (*b*), with the exception of the

inner tube of the last-mentioned, are made of brass. There is an advantage in having the vertical rod of the stand made of solid iron rather than of brass, and especially if the latter be hollow, as is generally the case, for the screws by which the different attachments are fixed at suitable heights to the rod, occasion indentations in the softer metal, which, from this cause, ultimately becomes so uneven as to render a readjustment of the positions of the different parts difficult. It is very important that each attachment, when the screw by which it is fixed is loosened, should move vertically or horizontally on the rod with perfect freedom, otherwise a sudden jerk may occasion the fracture of some part of the apparatus connected with it.

Cold water is supplied to the lower end of the condenser through the tube *c* from a vessel (fig. 312) which is made of copper or tin-plate. This cistern is furnished with a stop-cock (*b*), by which the stream of water is regulated. The heated water passes off from the condenser through the tube (*d*). The cistern (fig. 312), in addition to the stop-cock (*b*), has a tubular opening (*a*), which is usually stopped with a cork. The object of this is to admit of the insertion of a long tube, such as is shown in fig. 313, by means of which a stream of water may be conveyed to some distance from the cistern. [When a cistern with a stop-cock is not at hand, a continuous stream may be obtained by the use of a small glass or lead tube, bent as a syphon. The size of the stream may be regulated by a small wooden plug.—W. P.]

The flask, arranged as represented in fig. 314, presents a convenient form of apparatus for effecting distillation. Powders and other solid or liquid ingredients, are easily introduced through the open mouth of the flask without soiling the tube through which the vapours are conveyed, so that the distilled products are less likely to be contaminated with any non-volatile substances than is the case when a retort is used, through the long neck of which it is difficult to introduce the ingredients without some portion of them adhering to this part.

The contamination of the distilled products, occasioned by spirting,

Fig. 312.

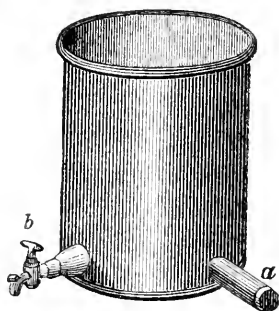


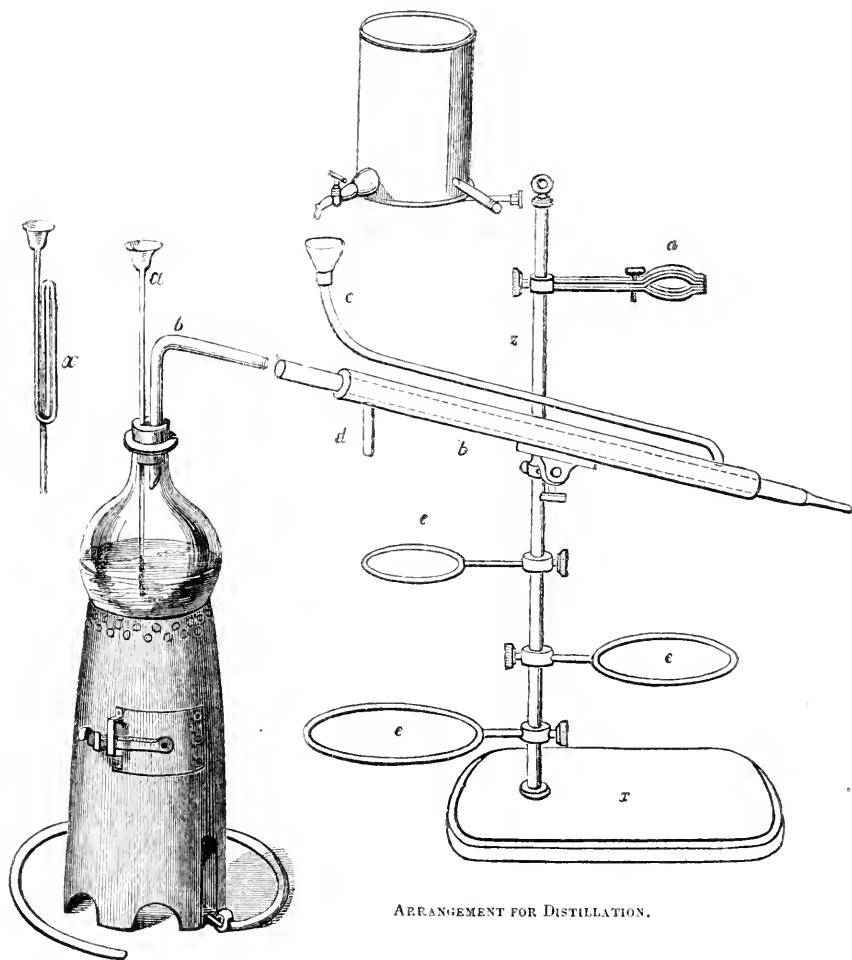
Fig. 313.



may also be easily obviated with the flask, by increasing the length of the lower limb of the tube (*b*), or by using the flask with the longer neck. The method represented in fig. 304 for obviating the effects of spirting when a retort is used, is neither elegant nor convenient.

There are some cases, however, in which the flask cannot be used, as, for instance, in the distillation of nitric acid or oil of vitriol. In

Fig. 314.



ARRANGEMENT FOR DISTILLATION.

fact, whenever the substance to be distilled acts chemically upon the cork, this form of apparatus must be considered objectionable, and should be replaced by the retort.

PROCESS OF DISTILLATION IN GLASS VESSELS.

The process of distillation is often accompanied with difficulties when effected in glass vessels, arising principally from the irregularity with which the ebullition and evaporation of some liquids takes place under these circumstances. The boiling-point of some liquids is several degrees higher in a glass vessel than it is, under the same atmospheric conditions, in a metallic vessel. There is also a difference in the manner in which these liquids boil in glass and in metallic vessels. In the latter, the ebullition takes place uniformly and without interruption; the bubbles of steam which rise through the liquid are small, and they are generated equally from all parts of the vessel equally exposed to the heat. In the former, the ebullition takes place less uniformly; the bubbles of steam are much larger, and they are generated only from a few points on the surface of the vessel, and there often by fits and starts.

The irregularity in the boiling of liquids in glass vessels is a frequent source of annoyance and perplexity to the operator in the chemical or pharmaceutical laboratory, constituting at its maximum degree, what is commonly called the "bumping" of the liquid.

Among the liquids which present this irregularity of ebullition to the greatest extent, may be mentioned *oil of vitriol*; the mixture for yielding *hydrocyanic acid*, according to the process of the Pharmacopœia; and aqueous, alcoholic, or ethereal liquids generally, which contain *resins* or *oleo-resins*, in solution or in suspension. It is impossible to effect the distillation of some of the last-named class of liquids in glass vessels. Thus, for instance, if a piece of common resin or of shellac be introduced into a flask (fig. 315) filled nearly up to the commencement of the neck with distilled water, and if the water be then boiled over the gas-furnace (fig. 84), the ebullition will at first take place pretty uniformly, but after some time it will be observed that the bubbles of steam which are formed at the bottom of the flask in contact with the most heated part of the glass, will be larger than they were in the first instance; and instead of their passing continuously through the liquid, there will be frequent intermissions, during which ebullition will entirely cease. After each of these intermissions the disengagement of steam will take place with increased violence, and, as the process is continued, the length

Fig. 315.



FLASK.

of the intermissions will become greater. If a thermometer be introduced into the flask, it will be found that this irregularity of ebullition is accompanied by great variations of temperature. While the bubbles of steam are passing freely through the liquid, the temperature will be from 212° to 214° Fahr., but when a cessation of ebullition takes place, the temperature will rise, and will sometimes reach 220° . This will be followed by a sudden and violent evolution of steam, constituting the phenomenon of *bumping*, by which the accumulated heat is disengaged, and the temperature of the liquid reduced again to its usual boiling-point. The violence of these explosions will, after some time, become so great as to cause the projection of a great part of the liquid at once out of the flask, endangering in no slight degree the safety of the operator.

This may be taken as a forcible illustration of the phenomena which accompany the bumping of certain liquids when boiled in glass vessels. It is rarely, however, that the effects are so decided as they are in the above case; nor am I aware that the phenomena, as here described, have been previously noticed.

Several explanations have been given by different writers with the view of explaining the cause of the bumping of liquids. It has been ascribed to the imperfect conduction of heat from the vessel in which the liquid is contained, the accumulation of heat on the surface of such vessel, and then its sudden transmission to the liquid; it has also been ascribed to a kind of *vis inertia* in the liquid, and to the absence of solid points at which the vapour might be generated.

These explanations, however, are very imperfect and unsatisfactory.

More recently, an explanation has been proposed, which ascribes the effects alluded to, to a modification of the forces of *cohesion* and *adhesion* in the liquid, caused by the expulsion of atmospheric air during the process of ebullition.

It may, indeed, be readily admitted that the immediate cause of the bumping of liquids is some modification of the forces of *cohesion* and *adhesion*; and that this condition is induced simply by the expulsion of air, is a position that will not be so readily assented to.

The three conditions which matter is capable of assuming, namely, the *solid*, the *liquid*, and the *aëriiform* or *gaseous*, are sometimes described as depending on two forces existing in different degrees, the one tending to attract or hold together the particles, the other tending to repel them or separate them asunder. In *solids*, the force of attraction is predominant; in *gases*, the force of repulsion prevails; while in *liquids*, it is stated, these forces are so equally balanced that the particles have perfect freedom of motion among each other.

It must not be supposed, however, that these forces are in a state of perfect equilibrium in liquids, or that the particles are not held together by a certain amount of *cohesive force*. It is easy to prove that this force of *cohesion* exists in all cases between the particles of a liquid. A good illustration of it is afforded in the familiar experiment of blowing a soap-bubble. This force may be roughly estimated by suspending a plate of glass to one end of the beam of a balance, adjusting the balance so that the glass shall be exactly equilibrated, then placing a vessel of water under the glass with the two surfaces parallel to each other, and allowing contact to take place. It will be found that some force will be required to break the contact, which may be estimated by the weights put into the opposite pan of the balance.

An exemplification of the force of *adhesion* existing between a liquid and a solid body with which it is in contact, is afforded in the instances of capillarity, which are familiar to every one.

It cannot be denied, then, that the forces of *cohesion* and *adhesion* exist; the former, between the particles of a liquid; and the latter, between the liquid and the vessel containing it. It will be evident, too, on considering what occurs in the boiling of a liquid, that these forces, in addition to the pressure of the atmosphere, have to be overcome by the repulsive influence of the heat. In the boiling of water, bubbles of steam are formed at the bottom of the vessel containing it; and as the particles of the liquid are separated from the surface of the vessel, as well as from each other, on the formation of each bubble of steam, it is evident that the tension of the steam thus generated, must be equal to the pressure of the atmosphere, *plus* the force of *cohesion* between the particles of liquid, or of *adhesion* between the liquid and the surface of the vessel containing it.

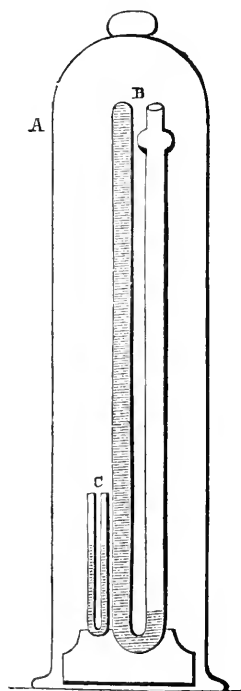
Now, when water is boiled in a metallic vessel, it has been found by Marcet, from some very carefully performed experiments, that the temperature of the steam after quitting the water, is about the third of a degree lower than that of the boiling water. This difference of a third of a degree, then, may be considered to represent a measure of the force of cohesion or adhesion in the water.

In glass vessels, the difference between the temperature of the steam after quitting the water, and that of the boiling water, amounts to more than the third of a degree, and this increased difference accords with the higher boiling-point of water in glass than in metallic vessels. It is inferred, therefore, that the forces of cohesion and adhesion are greater when water is boiled in glass than in metallic vessels.

But the results of these experiments afford a very inadequate indication of the extent to which the forces of *cohesion* and *adhesion* are capable of existing in water and other liquids. It appears, from the investigations of Mr. Henry, of Princeton, in America, and of M. Donné, a Belgian Chemist, that these forces frequently exist in liquids to a much greater extent than had previously been supposed.

Donné found that *oil of vitriol*, completely freed from air, introduced into the closed limb of an inverted syphon-tube, and placed under the receiver of an air-pump, is retained there in opposition to the force of gravity, through the power of cohesion and adhesion in the liquid.

The apparatus represented in fig. 316, will illustrate this experiment. The closed limb of the tube (B) is filled with oil of vitriol, and the corresponding limb of the smaller tube (C) is filled with mercury. The tubes being fixed to a stand, are placed under the receiver (A), over an air-pump, and the air is then pumped out. The tube (C) containing the mercury, will indicate the degree to which the receiver is exhausted. A great number of air-bubbles will be extricated from the oil of vitriol as the exhaustion proceeds, and it will be necessary to readmit the air into the receiver, and remove the portion of air which will be found to have collected in the top of the closed limb of B, as long as any air continues to be disengaged from the oil of vitriol, on exhausting the receiver. This will not be completely effected in less than six or eight days.



FORCES OF COHESION AND
ADHESION IN OIL OF VITRIOL.

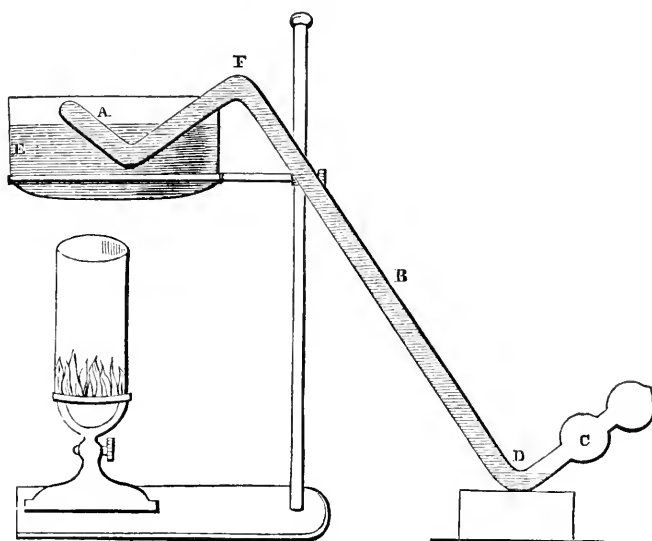
On commencing this operation, it will be observed that the height of the columns of oil of vitriol and of mercury supported in the sealed limbs of the tubes by the pressure of the atmosphere in the receiver, will be in the same proportion as the specific gravities

of the liquids; that is to say, that mercury being 7·3 times heavier than oil of vitriol, the column of oil of vitriol will be 7·3 times longer than that of mercury. Thus, when the column of mercury is half an inch, that of the oil of vitriol will be rather more than three and a half inches. When, however, the greater part of the air has been ex-

tracted from the oil of vitriol, the respective heights of the columns will no longer maintain this relation with any certainty. The oil of vitriol will frequently not fall in the tube (B) until long after the time at which such a result has been indicated by the column of mercury in C, and when it does fall, it will be observed that a little bubble of air is formed in some part of the column at the same moment. When the oil of vitriol has been deprived of air, so that air-bubbles are no longer formed in it, the receiver may be exhausted to the greatest extent practicable, without effecting any reduction in the column of oil of vitriol. The tube I have used is thirty-five inches long, and half an inch internal diameter, and a column of oil of vitriol of this length, has been supported in the sealed limb of the tube, as shown in the figure, while the column of mercury was less than half an inch.

Now, in this case, the pressure of the atmosphere in the receiver was equivalent only to a column of about three and a half inches of oil of vitriol, so that a column of this liquid, thirty-one and a half inches high, and half an inch in diameter, was supported by the forces of cohesion and adhesion.

Fig. 317.

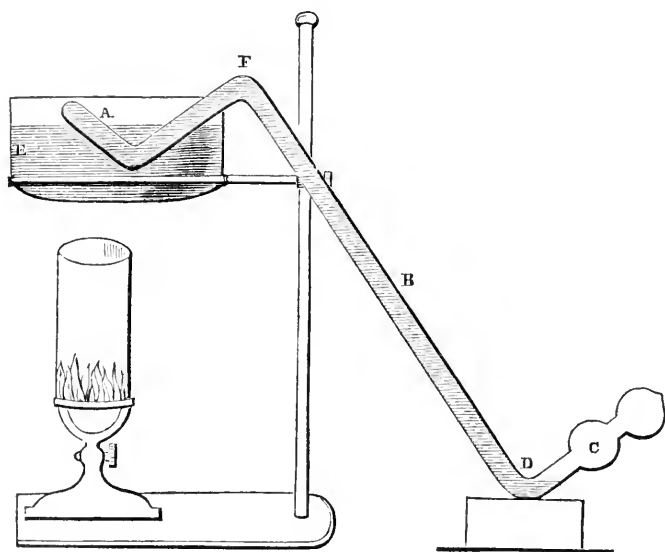


FORCES OF COHESION AND ADHESION IN WATER.

Having thus ascertained that the cohesive and adhesive power of a liquid are greatly increased when the air is entirely removed from it, *Donné* devised the following experiment, with the view of determining what the boiling-point of the liquid would be under such circumstances.

A tube (A, B, C,) containing as much water as will fill the limbs (A B) to the point (D) is deprived of air, and sealed in the way usually adopted in making a cryophorus. If the water be made to run into the end of the tube (A, B) and perfect contact between the water and the glass be insured by gently striking the end (A) on a table, it will be found that the tube may be placed as shown in the figure, without any of the water running out of B into C. The water is retained in the limb (B) by the forces of cohesion and of adhesion; and this will continue to be the case if the tube be placed so that B shall be perfectly vertical. If, now, a vessel (E) containing hot oil be placed as represented, so that the end (A) of the tube shall be immersed in the oil, the water in the tube from A to F will be heated, without any heat being communicated to the water in the limb (B), or to the vacuous part of the tube (C). Donné applied a bath heated to 212° to the tube arranged as described, but no ebullition took place, nor was

Fig. 318.



FORCES OF COHESION AND ADHESION IN WATER.

any vapour formed. He then increased the temperature of the bath to 234° , to 251° , and to 264° , but still there was no appearance of ebullition, or of the formation of vapour. On increasing the temperature to 275° , the water in the end (A) of the tube was suddenly converted into vapour, and the contents of the limb (B) were sent with great violence into the bulbs (C).

Now, if the water at A was really heated in this experiment to 275° before it entered into ebullition, the particles must have been held together by a cohesive force equivalent to the pressure of three atmospheres, or forty-two pounds to the inch; for water boils under this pressure at 275° Fahr.

From these experiments Donné infers that water boils at 212° under the mean pressure of the atmosphere, only when it contains a certain portion of air in solution, the action of the air being to destroy or to lessen the force of cohesion and of adhesion in the liquid; and he ascribes the irregularity and the bumping which occur in the boiling of liquids, to increased cohesive and adhesive power caused by the disengagement of air in the process of boiling. He has proposed, as a remedy in these cases, that air should be passed through the liquid from a tube.

Interesting as are the experiments of Donné, it cannot be admitted that they are sufficient to justify the conclusion he has drawn from them. I have repeatedly tried his proposed remedy in cases of irregular ebullition, but have not found it successful. Moreover, the proposed theory does not offer a rational explanation of some of the phenomena in question. It was found by Marcet that if pure water be put into a glass flask which has previously had *oil of vitriol* heated in it, the boiling-point of the water will sometimes rise as high as 220° ; while, on the other hand, if the inner surface of the flask be coated with a thin film of *shellac*, the boiling-point of pure water heated in it will be sensibly below 212° . In a metallic vessel the same liquid would boil precisely at 212° , and in a glass vessel in its usual condition, without any previous preparation, the boiling-point would be a little above 212° . In these cases the boiling-point of the liquid appears to have some relation to the condition of the surface of the containing vessel, and to be unconnected with the presence or absence of air in the liquid.

There are other cases in which certain substances, dissolved or suspended in the liquid, occasion variations in the boiling-point as great as those above noticed. Some salts, and especially resins and oils, belong to this class; and it is worthy of remark that the same substance, shellac for instance, when spread over the surface of the glass, produces an effect the opposite of that which occurs when the same substance is suspended in the liquid. In the one case the boiling-point is reduced, while in the other it is raised to the extent of seven or eight degrees. But these variations, caused by the presence of substances dissolved or suspended in the liquid, do not occur in metallic vessels. The water containing shellac, which boils at 220° in a glass

flask, if put into a metallic vessel will boil steadily at 212° , without the slightest tendency to bumping. Indeed, I have invariably found that liquids, the ebullition of which in glass vessels is accompanied by even the most violent bumping, present no such phenomenon when boiled in metallic vessels.

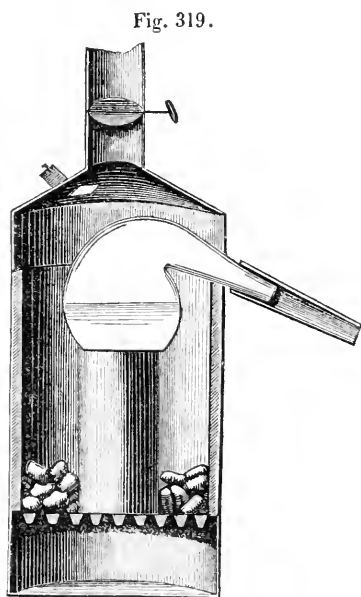
It appears, therefore, that the effects under consideration do not depend wholly on the state of the liquid, nor on that of the vessel containing it, but partly on each.

The *distillation of oil of vitriol*, which is sometimes effected with a view to the purification of the acid, presents an instance in which there is both difficulty and danger, from the irregularity of the ebullition of this liquid in glass vessels. The introduction of pieces of platinum wire or clippings into the retort, has been proposed as a method of obviating this difficulty, but this is not found to be a complete remedy for the evil. Dr. Mohr suggests the following method of conducting the distillation.

A glass retort, of about two pounds capacity, is placed on a cylinder of sheet-iron in the centre of a small iron furnace (fig. 319), while its short neck protrudes through an opening in the side of the furnace. Ignited charcoal is placed around the cylinder, without being allowed to come in contact with the glass, and a current of hot

air is thus made to play on all parts of the retort excepting the bottom, which is protected by its support. There is a valve in the flue of the furnace for regulating the draught, and three small doors in the cupola or head for supplying fresh fuel on every side, and for observing the progress of the distillation.

The process should be conducted cautiously, and without the application of an unnecessary degree of heat. The means of condensation which I am accustomed to adopt, consists simply in the application of a thin glass tube, about four or five feet in length, to the projecting neck of the retort. These are made to fit to



DISTILLATION OF OIL OF VITRIOL.

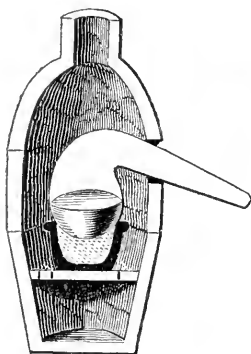
each other without the use of luting, which would be inadmissible, and

the lower end of the tube is somewhat contracted, to prevent currents of air from ascending through it.

With this arrangement the distillation takes place without much danger or difficulty.

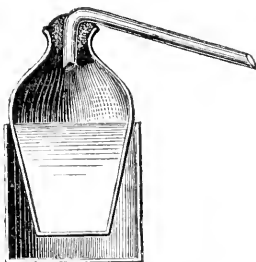
Instead of the sheet-iron cylinder, a Hessian crucible might perhaps be employed, and this, if requisite, might be elevated by placing it on a brick. An arrangement of this kind is shown in fig. 320.

Fig. 320.



DISTILLATION OF OIL OF VITRIOL.

Fig. 321.



DISTILLATION OF OIL OF VITRIOL.

I have sometimes used a stoneware bottle, such as is frequently met with in commerce. A bent glass tube is fixed in the neck of the bottle by means of plaster of Paris, the acid being previously introduced. This arrangement is shown in fig. 321. The tube should be three or four feet in length, so as to act as a condenser.

Retorts of porcelain, or of good stoneware, offer great facilities in conducting this process, but these are not always to be obtained.

In the manufacture of oil of vitriol, the process of distillation, by which the acid is concentrated, is now always conducted in platinum stills, which have superseded the glass retorts originally used. This substitution has rendered the process, which was formerly a hazardous and difficult one, perfectly safe and easy. The result confirms the statement already made with regard to the influence of a metallic vessel. But platinum stills are too expensive for laboratory use, and other means have therefore been sought for facilitating the distillation of oil of vitriol.

A French chemist, M. Lambert, has proposed the use of fragments of a species of quartz (*quarzite*), which are introduced into a glass retort. These fragments should be angular and not very small. About a dozen pieces, each from a quarter of an inch to half an inch

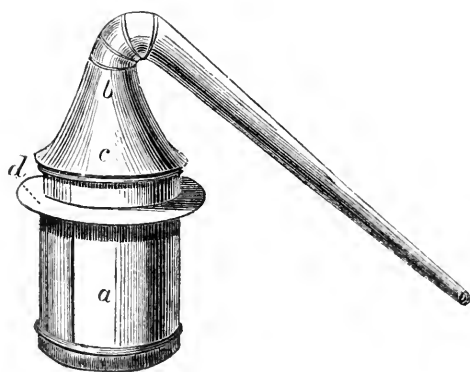
in length, will render the distillation of several pounds of the acid quite manageable. I have used fragments of *rock crystal* in the distillation of *balsam of copaiba*, essential oils, and other similar substances, in glass vessels, and have found that by this means the inconvenience otherwise experienced in conducting the process has been entirely obviated. Pieces of rock crystal suitable for this purpose, consisting of the chippings formed in making spectacle glasses, may be obtained at a lapidary's or optician's. These pieces, which contain only pure silica, may be used in processes of this kind without the fear of contaminating the resulting products.

It might be supposed that broken fragments of glass, or sand, would answer the same purpose as quartz or rock crystal, but such is not the case.

[If a process of distillation has been commenced, and the bumping occurs, as for instance, in distilling ether from the oleo-resin of cubebs, the temperature should be allowed to fall below that of the boiling-point of the ether, before introducing the fragments of quartz or glass, else a large quantity of vapour will be suddenly eliminated, and cause the contents of the retort to overflow.—W. P.]

The presence of small fragments of rock crystal in the flask or retort, appears, in all cases, as far as I have observed, to prevent the occurrence of bumping; but when the object of the process is to obtain and preserve the residue from which the more volatile parts have been separated by distillation or vaporisation, it may be found inconvenient to have any foreign matter mixed with it. In cases of this

Fig. 322.



SMALL PLATED STILL.

kind a small metallic still may be sometimes used with advantage. Such an apparatus is represented in fig. 322. It is made of copper, thickly plated on the inside with silver, and is used with the gas-furnace (fig. 84), on the top of which it is supported by the collar *d*. The head (*b*) fits on to the body (*a*) at *c*, so that when the former is removed, any resinous or

other solid matter can be easily taken out, and the apparatus com-

pletely cleaned. It may be used either with or without the head, for concentrating caustic solutions of potash or soda.

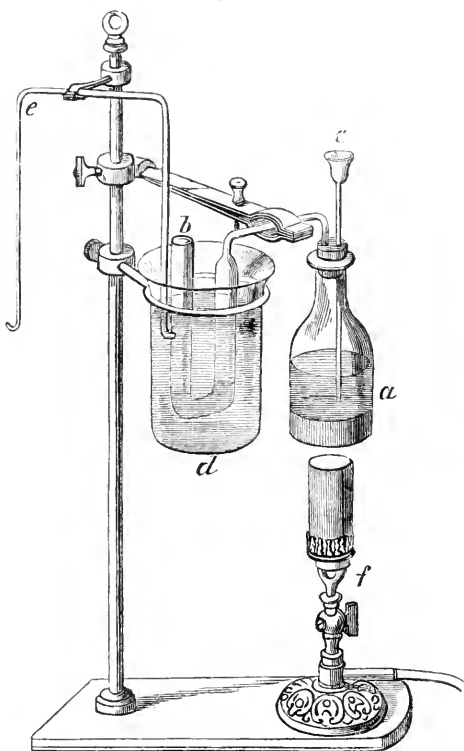
In some processes glass vessels, partly coated on the inside with silver, may be conveniently used. Fig. 323 represents an arrangement of apparatus for distillation, in which a flask (*a*) is employed, the bottom of which is thus coated. It has the advantage of presenting a metallic surface to the liquid, in the part most exposed to the heat, while the contents of the vessel are unobscured from view. The silver is deposited on the glass by the process of Mr. Drayton, in which the two following solutions are used.

1. *Solution of silver*.—Dissolve twenty-five grains of nitrate of silver in about an ounce of distilled water, and add to it some pure caustic ammonia, drop by drop, until the precipitated oxide of silver is redissolved, carefully avoiding the use of more ammonia than is necessary; then add sufficient distilled water to make twenty ounces of clear solution.

2. *Solution of essential oils*.—Dissolve half a fluid drachm of oil of cloves, and the same quantity of oil of cassia, in three fluid ounces of rectified spirit of wine.

In silvering glass vessels by this process the *solution of silver* is introduced into the vessel so as to cover the part intended to be silvered, and the *solution of essential oils* is then added in the proportion of one drachm of the latter to every ounce of the former. The mixture first becomes milky, and subsequently assumes a dark or blackish appearance, while at the same time metallic silver is deposited on the surface of the glass. It will be several hours before

Fig. 323.



APPARATUS FOR DISTILLATION.

this deposition is completed, during which time the solution should be left undisturbed. The liquid may then be poured out, and the vessel cleaned from adhering oil by means of spirit of wine, several successive quantities of which should be boiled in it, until the surface of the deposited silver becomes perfectly clean and bright, and no smell of the oil remains.

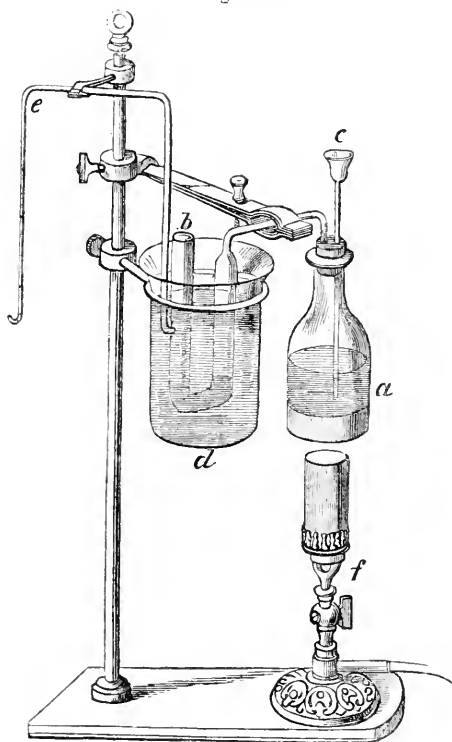
It is important that the essential oils used in this process should not be old or resinified, as in this case the silver would be deposited not in a bright metallic state, but in the form of a dirty blackish-brown powder, a result which would also ensue if the oils be added in undue quantity. It may be sometimes necessary to vary the quantity to a slight extent, according to the quality of the oils used.

When the process has been successfully performed, and every trace of oil removed with spirit in the manner described, the coating of

silver may be rendered thicker by depositing a fresh portion of metal, from a solution of oxide of silver in cyanide of potassium by electricity.

Glass vessels may also be covered with platinum, by putting into them a solution of the chloride of that metal, adding thereto some formic acid, and then boiling the mixture. The coating of metallic platinum thus obtained, will not, generally, be so perfect and uniform, as that of the silver deposited by the preceding process, but I have frequently succeeded in getting a deposit of perfectly bright platinum in this way, which has adhered very strongly to the glass, and has not been separated by the action of strong acids and other

Fig. 324.



APPARATUS FOR DISTILLATION.

substances repeatedly boiled in the vessel.

The arrangement of apparatus shown in fig. 324, is convenient for

distilling small quantities of liquid. It consists of a flask (*a*), through the cork of which a tube-funnel (*c*) passes for the supply of fresh liquid, if required; a bent tube (*b*), which forms the receiver; and a beaker (*d*), nearly filled with cold water, by which the condensation is effected. The tube (*b*) being inserted through the cork of the flask, is supported by the *Gay-Lussac holder*, and immersed in the contents of the beaker, which is placed in one of the rings of the retort-stand. The syphon (*e*) is used for removing the water, heated in the process of condensation, from the upper part of the beaker, when cold water is from time to time poured in through a tube-funnel reaching to the bottom. This syphon may also be employed for withdrawing the condensed liquor from the tube (*b*). The manner of using it in cases such as these has been described at page 183. Heat is applied to the flask by the gas-lamp (*f*).

[*Distillation of Hydrocyanic Acid.* The distillation of hydrocyanic acid for medicinal use is attended with several circumstances that are worthy of note. The U. S. P. formula directs that a solution of ferrocyanuret of potassium be placed in a retort arranged for distillation, diluted sulphuric acid afterwards added, and the mixture then distilled until a certain measure of fluid has passed over into the recipient, which previously contained a portion of distilled water. In practice, it is more convenient to use a large flask and a Liebig's condenser, instead of a retort, and a graduated bottle in place of a globular receiver. The flask should have a wide, rather long neck, like fig. 315, so that during the bumping that is liable to occur, none of the contents of the retort shall be thrown beyond the curve of the tube that connects the flask with the condenser. There should also be a safety-tube, fig. 325, connected with the flask. The heat should be applied by means of a sand-bath, and the thin wrought-iron hemispheres, sold by the iron-mongers for the bowls of ladles, are very suitable, a thin layer of sand being placed between the flask and the iron. The inferior end of the condenser tube should be bent down, so as to be inserted through a cork, into the neck of the graduated bottle containing the distilled water. All the joints being luted, or covered with caoutchouc, the heat is applied by means of a gas-burner, or an alcohol lamp. As soon as ebullition commences, there is a liberation of hydrocyanic acid vapour, which causes considerable outward pressure, unless the refrigeration is very complete. For this reason the water used should be cooled with ice. The distilled water

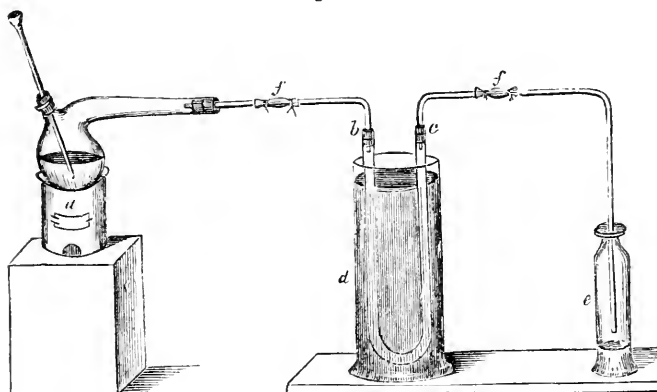
Fig. 325.

SAFETY
TUBE.

contained in the graduated bottle is intended to absorb this vapour, and it also should be kept cool. The distillation is proceeded with until the amount of the distillate, as indicated by the graduation on the receiving bottle, shall equal that called for in the formula. The subsequent steps of the process for testing and diluting the acid, are not in place here.

When it is desired to make anhydrous, or very concentrated hydrocyanic acid, the apparatus, fig. 326, recommended by Wohler, may be used. The retort contains a concentrated solution of cyanide of potassium, free from cyanate of potassa, and its beak is connected with a U-shaped condensing tube *b c*, which is also connected by a bent tube with the receiving vial *e*. The U-shaped tube is filled

Fig. 326.

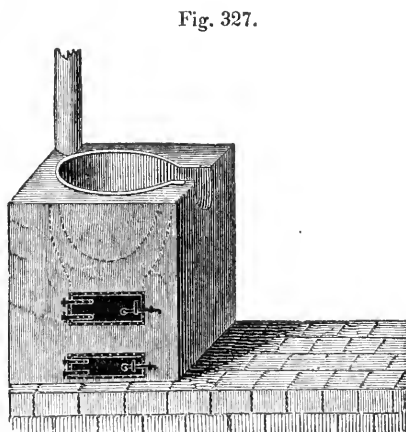


WOHLER'S APPARATUS FOR ANHYDROUS HYDROCYANIC ACID.

with small fragments of chloride of calcium, except the upper part of the limb *b*, which contains pieces of cyanide of potassium, and is placed in a deep glass vessel *d*, filled with ice-cold water. The vial *e* is surrounded by a mixture of snow, or ice and salt, up to the neck. All the joints being luted, a mixture of equal parts of sulphuric acid and water is poured into the retort gradually, through the funnel-tube, which causes the liberation of a large quantity of hydrocyanic acid vapour, that passes over and is arrested in the bent tube. As soon as the requisite quantity of acid has been added to the retort, and the reaction ceases, the cold water is decanted from *d* with a syphon, and its place filled with water at 85° or 90° Fahr., and heat applied to the retort. The hydrocyanic acid then passes rapidly over, the aqueous vapour only being arrested by the chloride of calcium, and is condensed in the vial *e*, which is kept surrounded by a freezing mixture.

This process of Wohler's for making anhydrous prussic acid, gives a general idea of the mode of proceeding in the distillation of very volatile liquids requiring tube apparatus.—W. P.]

When retorts of a large size are employed in the process of distillation, it becomes necessary to have a furnace and sand-pot expressly adapted for their reception, as represented in fig. 327. The sand-pot should be of cast iron, and of such a size that, when the retort is put in, there shall be a stratum of sand of about an inch in thickness between them. The intervening sand should never exceed this thickness, for in such case there would be unnecessary consumption of fuel, and, moreover, it would be much more difficult to regulate the heat. When there is a great thickness of sand between the retort and the iron pot, the heat, if accidentally raised too high, is retained for some time by the sand, and cannot be speedily reduced by removing the fire, or checking combustion.



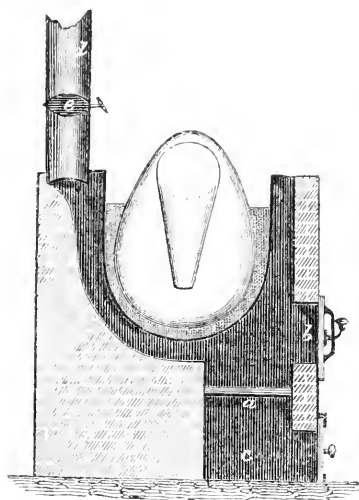
FURNACE AND SAND-POT FOR DISTILLATION WITH
A RETORT.

The construction of the fire-place, and position of the fire in relation to the sand-pot, are also of some importance. The grate should not be immediately underneath the sand-pot, but a little in front of it, as shown in fig. 328. This drawing represents a section of fig. 329, in the direction of the lines A, B, C, D.

The combustion and intensity of the heat are regulated by means of the valve (*e*) in the chimney, the sliding door of the ash-chamber (*c*), and the door (*b*) of the fire-place. When a strong fire is required, the valve (*e*) and the door of the ash-chamber are kept open, and the door of the fire-place closed. As soon as the apparatus has been brought into full operation, the valve may be partially closed, by which means a saving of fuel is effected without diminishing the available heat. If the fire should become too strong, the combustion may be checked by partially closing the door of the ash-chamber and contracting still further the valve in the chimney, or by opening the latter to the fullest extent, and at the same time closing entirely the door of the ash-chamber. Should even this be insufficient, the door

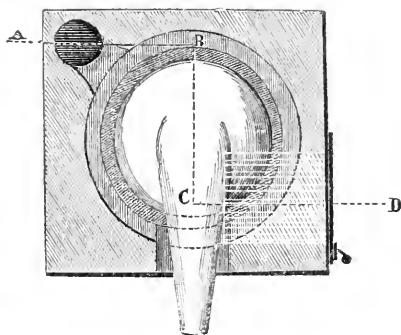
of the fire-place must be opened, so as to admit a current of cold air to pass in contact with the bottom of the sand-pot.

Fig. 328.



RETORT IN SAND-POT.

Fig. 329.



In fig. 329, the position of the fire-place is shown, as indicated by the white lines in the part between C and D.

Fig. 330.

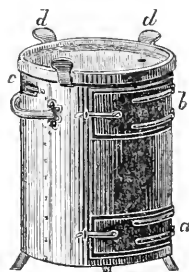
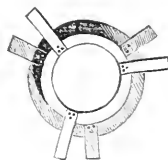


Fig. 331.



Fig. 332.

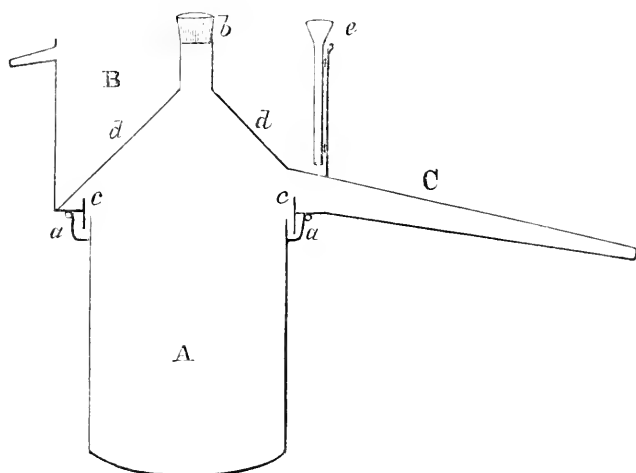


PORTABLE FURNACE AND APPENDAGES FOR DISTILLATION.

Fig. 330 represents a portable furnace, which would sometimes be found useful in processes of distillation. It is designed only for a charcoal fire, and the fuel is supplied during the continuance of the process, through the door (*b*). The supports (*d, d, d*) are intended for the reception of any large vessel which may be placed over the fire. The sand-pot (fig. 331), or the rings (fig. 332), are used for supporting retorts.

[There is a distillatory apparatus which has been used to some extent in Philadelphia, and which for the sake of distinction may be called a *pharmaceutical still*, from its applicability to the wants of the pharmacist. Fig. 333 exhibits a section of this still, which shows its construction better than a full figure of the apparatus. A, is the cucurbit or boiler, which ordinarily holds two gallons, but may be made of any size; B, is the dome or head, on the inner surface of which the condensation occurs, and C the neck or tube connected with

Fig. 333.



PHARMACEUTICAL STILL.

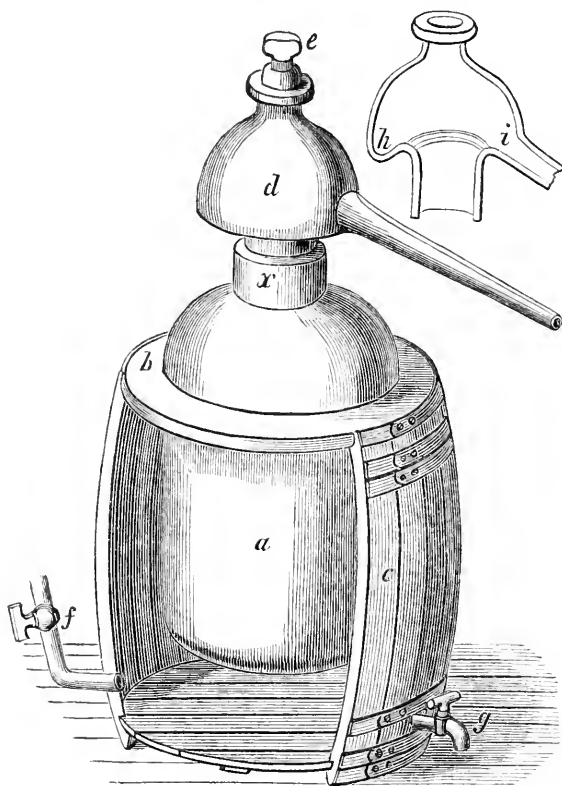
the recipient, and which is soldered to the head, and opens into it. *a a* is a rim, soldered around the mouth of the boiler, so as to form a water-joint; *c c*, is a circular rim, soldered on the base of the head, in such a manner that the upper part forms a gutter for conducting the condensed fluid from the base of the condensing cone, *d d*, to the neck, C, whilst the lower part projects below into the double rim of the boiler, *a a*, to form the water-joint. *b* is an opening corresponding to the tubulure of a retort, which enables the operator to inspect the progress of the distillation, and to stir the contents of the still when necessary. This opening is stopped with a cork, or a tin cap. *e* is a funnel-tube into which a current of cold water runs during distillation, the warm water running off by the tube on the opposite side.

In using this apparatus, the water-joint should be two-thirds filled with water, the materials introduced, and the head adjusted and filled with water. The neck C, may be connected with a worm, if the fluid distilled is alcohol; if aqueous, all that is necessary is to insert into

it, through a cork, a bent tube, to convey the product to a suitable receptacle. If the water on the head is kept sufficiently cool, but little vapour will escape uncondensed. This still is used with great advantage for regaining the alcohol from tinctures designed for syrups and extracts, and for the distillation of water. It is best used by inserting the boiler into the top of an ordinary cylindrical coal stove, so that the rim of the water-joint shall rest on the edge of the stove after the top has been removed. The whole apparatus is constructed of tinned iron, at a moderate cost.—W. P.]

Fig. 334.

Fig. 335.



STONEWARE STILL.

The stoneware still (fig. 334) is a convenient form of apparatus for some processes in the pharmaceutical laboratory, as for instance, in the distillation of *vinegar*, *sweet spirit of nitre*, *spirit of sal volatile*, &c. The quantities of ingredients operated upon in these processes, which are necessarily conducted with glass or earthenware vessels, are such, that, if a retort be used, there is much danger of breaking it in

consequence of its size. The charging of a large retort, capable of holding several gallons, its introduction into the sand-bath, and its subsequent removal when the process is finished, are attended with much hazard; and the occasional fracture of the vessel, and loss of its contents, are almost inevitable results. These sources of loss and annoyance are entirely avoided by substituting the apparatus (fig. 334) for the retort. The body (*a*) of the still is made of brown earthenware, commonly called stoneware. It has a projecting rim (*b*), by means of which it may be easily fixed in a jacket or case, when heat is applied through the medium of steam. The head (*d*) may be made of the same material as the body, or it may be made of glass. It should have the form represented in the drawing, and which is more clearly indicated by the section, fig. 335. The object in adopting this form is, to prevent any liquid condensed in the head from running back into the body. Such liquid, being collected in the groove (*h*), runs off through the tube (*i*) in the direction of the receiver. There is a stopper (*e*) at the top of the head, which admits of the introduction of fresh ingredients during the continuance of the process if desired.

This still may be heated by means of the furnace and sand-pot (fig. 327), in the same way as a retort; but the drawing represents the arrangement adopted

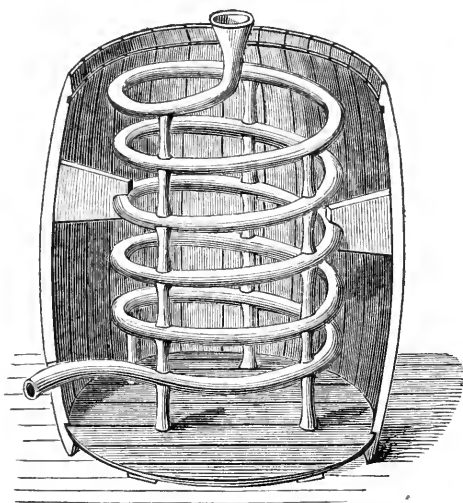
when steam is used as the source of heat. The still is fixed in a cask (*c*) of suitable size, to which steam is supplied through the pipe (*f*). On first turning on the steam, the air is allowed to escape at the stop-cock (*g*), from whence also the condensed water runs off.

The *Stone-ware condenser*, (fig. 337,) and the *adapter*, (fig. 336,) are used with the still. These are all made by the manufacturers of

Fig. 336.



Fig. 337.



STONEWARE CONDENSER.

stoneware apparatus for chemical purposes, of whom there are several in the vicinity of Vauxhall Bridge, London. The stoneware worm may be fixed in a cask, similar to that used as the jacket of the still.

This kind of condenser answers very well, and is the most suitable for the distillation of *sweet spirit of nitre*, or *vinegar*, but it would be inapplicable in the process for the preparation of *spirit of sal volatile*. In distilling this last-named spirit, the carbonate of ammonia, which it contains, is frequently deposited in considerable quantity in the condenser, and would soon block up a worm such as that represented in fig. 337. The best kind of condenser for the distillation of this spirit, is that represented at page 118, figs. 115 and 116; but the tube should be of much larger diameter than that mentioned in the description there given.

THE DISTILLATION OF ESSENTIAL OILS.

The method of proceeding in the distillation of essential oils is very similar to that adopted in making the medicinal distilled waters. The object contemplated in both cases is, to effect the volatilization of the essential oils contained or formed in the substances operated upon, together with water, and thus to separate these from the fixed or less volatile parts with which they were associated.

In making *distilled waters*, a sufficient quantity of water is used in the process to dissolve the whole, or nearly the whole, of the oil afforded by the other ingredients, so as to form a saturated solution.

In conducting the process with the view of obtaining the *essential oil* alone, the smallest possible quantity of water is employed, so as to avoid unnecessary loss of the required product by its solution in the water.

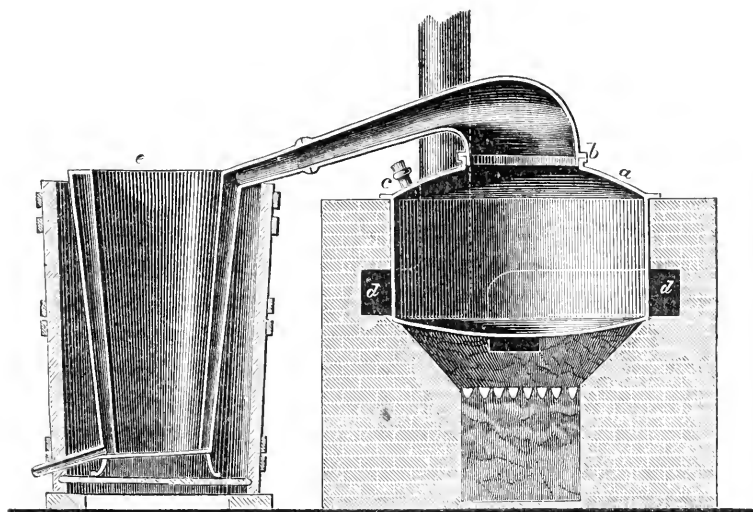
The quantity of water added to the other ingredients constitutes, therefore, the principal difference between the two processes.

The essential oils employed in pharmacy are obtained from different parts of vegetables, in which they are generally contained in cells, and sometimes associated with other constituents of the plant, such as fixed oil, resin, or wax. It is important that these oils should be separated and collected without exposing them to a high temperature, and their distillation is therefore effected at temperatures below their boiling-points, by distilling them together with water. The boiling-points of these oils are much higher than that of water. Thus, the boiling-point

Of oil of mustard	is	290° Fahr.
“ turpentine	“	314° “
“ mint	“	320° “
“ cajuput	“	343° “
“ thyme	“	354° “
“ bitter almonds	“	356° “
“ peppermint	“	365° “
“ rosemary	“	365° “
“ meadow-sweet	“	380° “
“ pennyroyal	“	395° “
“ gaultheria	“	412° “

But although any one of these oils, if submitted to distillation without the admixture of any other more easily volatilized substance, would require to be heated to the temperature above represented as its boiling-point, yet, when mixed with water, it will readily distil at 212°, that is, at the boiling-point of the water. This occurs through the tendency to diffusion of the less volatile liquid into the vapour of the

Fig. 338.



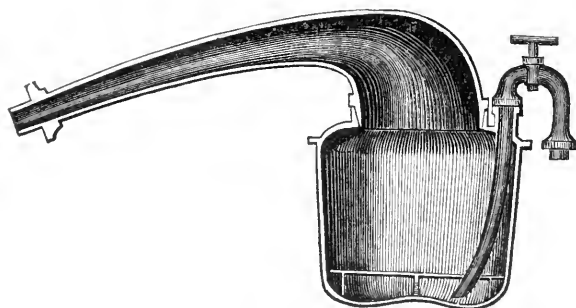
STILL AND CONDENSER.

more volatile, in accordance with the principles explained at pages 298 and 299.

It is thus that the distillation of essential oils is always effected. The vegetable substance from which the oil is to be obtained, if it consist of root, wood, bark, fruit, or seed, is generally cut or bruised,

so as to facilitate the extraction of the oil. It is then either introduced into the body of the still (fig. 338), together with a suitable quantity of water, and, after being allowed to macerate for some time, is submitted to distillation in the usual way, or it is put into a vessel such as the cucurbit (fig. 339), and steam being allowed to issue from a pipe beneath the perforated false-bottom (fig. 340), is made to pass through it into the condenser.

Fig. 339.



CUCURBIT AND FALSE-BOTTOM.

Fig. 340.

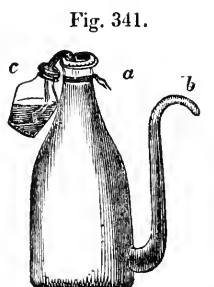


PERFORATED FALSE-BOTTOM.

Some difference of opinion exists as to which of these two methods of operating is the best. The former, when conducted in a still set over the fire, as represented in the drawing, is subject to objection in consequence of the danger there is of applying too much heat, and thus injuring the quality of the oil by contaminating it with the products of the decomposition of vegetable matter. In the latter method of operating, the above objection does not apply; but it is difficult, if not impossible, to draw over the whole of the oil in this way, without using so much steam that the product in undissolved oil will be very small, as compared with that obtained by the other process.

At Mitcham, where large quantities of essential oils are distilled for the London market, the process is conducted with common stills, set as represented in fig. 338. These stills are generally of great magnitude, having, sometimes, a capacity of two or three thousand gallons. The bottom of the still is covered with wicker-work, or with perforated boards, over which the vegetable substance to be operated upon is placed, and the body of the still being thus nearly filled, water is introduced so as just to cover the solid ingredients. It is customary to allow some hours to elapse, after charging the still, before commencing the process of distillation; the fire is then lighted, and water saturated

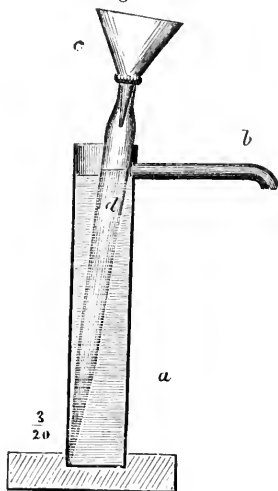
with essential oil passes over, together with a portion of oil beyond that which the water is capable of holding in solution. The distilled products, if the oil be lighter than water, are received into a vessel (fig. 341), called the *Florentine receiver*. The oil collects here in the neck of the vessel at *a*, while the water flows off into another vessel through the spout *b*. The small bottle (*c*), represented as attached to the neck of the receiver, is not used in this part of the process, but in a subsequent operation, which is described at page 354.



THE FLORENTINE RECEIVER.

If the oil be heavier than water, the form of apparatus (fig. 342) may be conveniently adopted for collecting it. This consists of a vessel (*a*), near the top of which there is a spout (*b*) through which the water flows into a suitable receiver, as fresh portions are supplied through the long funnel (*c*, *d*). The oil, being heavier than the water, collects at the bottom of *a*.

Fig. 342.



OIL-SEPARATOR.

This apparatus may also be used for collecting and separating oils that are lighter than water, which application of it will be described hereafter.

When the object of the process is merely the collection of essential oil, the distilled water which comes over with it, and from which the oil has been separated as above, is used, on re-charging the still, instead of common water, by which means a larger product of oil is obtained, to the extent of the portion held in solution by the water.

Some oils pass over more slowly than others, being either less volatile, or more tenaciously held by the vegetable matter. In these cases, it is sometimes necessary to return the distilled water two or three times on to the solid ingredients before the whole of the oil is extracted.

The utmost care should be taken, in this process, to prevent the distilled product from acquiring any empyreumatic impregnation, which might be acquired by the incautious application of heat, or the continuance of the process until carbonization of some of the vegetable matter has commenced. In operating with the common still (fig. 338)

it is very difficult to avoid these results, and hence the reason that other methods of conducting the process have been resorted to. The substitution of steam apparatus for the still set over the fire, affords the best means of remedying the evil alluded to. If a still such as that represented in fig. 132, p. 135, be employed, the process may be conducted without any fear of injuring the product by excessive heat. The only objection to this arrangement is, that there is much loss of heat by radiation from the steam-pipes, and the outer surface of the steam-chamber of the still, which occasions an undue consumption of fuel. The loss of heat by radiation is diminished when the steam is conveyed directly into the interior of the distillatory vessel, as represented at S T, fig. 132, and the process then conducted in the manner represented in fig. 339; but although this method answers very well for preparing most of the distilled waters, it is not, as already stated, completely efficient in the distillation of essential oils, especially of those which are the least volatile.

There is another method of applying steam for distillation or vaporization, in which the objections which apply to the two foregoing methods are obviated. It consists in heating the liquid by means of a coil of steam-pipe fixed within the still or boiler. This pipe, through which steam at a suitable temperature is passed, being surrounded by the liquid, parts with no heat that is not rendered available. It is found to be the most economical and efficient method of applying the steam, and may be beneficially adopted for processes in which the presence of the steam-pipe within the boiler is not objectionable. In operating in this way, a strong cask may be readily converted into a still by fixing a coil of steam-pipe within it, somewhat in the manner represented in fig. 337; but the pipe should be more nearly in contact with the sides of the cask than is there represented, if much solid matter is to be put in, and the head of the cask should, of course, be retained, with a suitable opening for introducing and removing solid ingredients, and a pipe for conveying the vapour to a condenser.

So important has the avoidance of the application of a high temperature been considered with reference to the preparation of essential oils, that it has been proposed to effect their distillation *in vacuo*, with apparatus similar in principle and general arrangement to that represented in fig. 278. Oils that have been thus prepared are said to be superior to those obtained in the ordinary way, and the chief obstacle to the adoption of this process is, probably, the expense of the apparatus.

The quality of essential oils, and distilled waters, however, does not

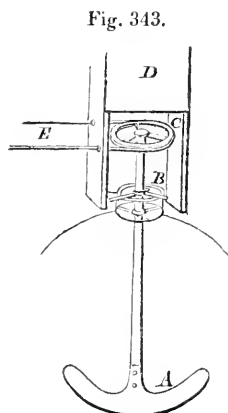
depend solely on the process by which they are distilled. When obtained from fresh plants, leaves, or flowers, it is important that these should be collected at suitable periods with reference to the growth of the plant. Labiate plants are said to yield the best oils when they are just beginning to flower, although the quantity yielded is greater at a later period of their growth. In the distillation of roses, the petals only should be used, and not the entire flower including the calyx. In like manner, elder flowers should be stripped from the stalks. When seeds, fruits, or other parts, are bruised or otherwise disintegrated, previously to submitting them to distillation, the one process should immediately precede the other, for if they be much exposed to the air after being so prepared there will be both diminution of product and deterioration of its quality.

There are a few substances in obtaining essential oil from which it is necessary to conduct the process of distillation in a particular manner. *Bitter almonds, mustard seeds, and horseradish*, are of this class. These substances do not contain essential oil ready formed, but the oil is produced in the process to which they are submitted. *Bitter almond cake*, for instance, from which essential oil and distilled water are obtained, contains two bodies, *amygdaline* and *emulsine*, by the mutual reaction of which, together with water, the oil is produced. Black mustard-seed, also, contains two analogous bodies, *myronic acid* and *myrosyne*, which in like manner produce the essential oil of mustard. Bodies of analogous nature exist in *horseradish* and in *laurel leaves*. The *emulsine* and the *myrosyne* of the almond and the mustard-seed, and the corresponding substances in the other plants mentioned, undergo a change, similar to the coagulation of albumen, when heated to a temperature approaching that of boiling water, and when thus coagulated they are no longer capable of producing essential oil with the other vegetable principles. It is necessary, therefore, in obtaining essential oil from this class of substances, to macerate them with cold or luke-warm water for some time previously to the application of heat. If boiling water were added at once to these substances, it would coagulate and render inoperative one of the constituents from which, under other circumstances, the oil would be formed.

In distilling *bitter almonds*, the cake, which has been previously freed from fixed oil by expression, is powdered and mixed with about twenty parts of cold water. The mixture is allowed to stand for twenty-four hours before the application of heat, during which time the essential oil is produced; it is then submitted to distillation. The mixture, after being boiled, and especially when part of the water has

been distilled off, becomes thick, and is apt to adhere in a hard cake to the inner surface of the still; and if this be allowed to remain there, it will greatly retard the progress of the distillation by obstructing the free conduction of heat to the more liquid part; while, at the

same time, the product may be contaminated with an empyreumatic flavour from the action of the heated metal on the caked vegetable matter. To obviate these results, it is customary to have an apparatus, technically called a *rouser*, attached to the still, by which constant agitation of the ingredients may be effected.

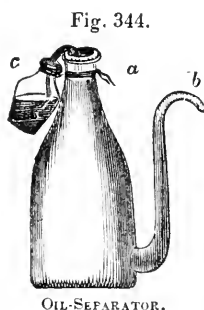


THE ROUSER.

Fig. 343 represents an arrangement of this kind, but in addition to the projecting arms (A), chains are sometimes attached, which are dragged along the bottom of the still as the agitator is turned.

After obtaining the oil by distillation, and collecting it in the Florentine receiver, it has to be separated from the water, on the surface of which it floats. If the quantity of oil be small, and there be no better arrangement at

hand for the purpose, the separation may be effected as follows:—the spout (b) of the *Florentine receiver* (fig. 344), in which the oil has been collected, is stopped with a cork, and water is poured in until the oil rises to the top of the neck at a; a small bottle (c) is then tied to the neck of the receiver, and a few threads of lamp-cotton placed as represented, so as to form a syphon, through which the oil will be conveyed into the bottle by capillary attraction.



OIL-SEPARATOR.

If the quantity of oil be such as to render this method of proceeding tedious or inapplicable, one of the *oil separators*, figs. 345 and 346, may be used. The apparatus, fig. 345, consists of a funnel, terminating in a small tube at the bottom, and contracted at the top so as to admit of its being closed by the thumb of the operator, or by a cork or glass stopper. The opening at the bottom is closed by the finger, or by inserting a small cork, when the liquid is poured into the funnel; and when the oil has collected on the surface of the water, the latter is allowed to run off either by opening the lower tube, or,

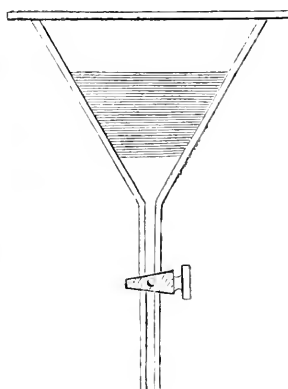
the latter being left open, by allowing air to enter at the top. This apparatus is sometimes made with a stop-cock, as represented in fig. 346, and it is then much more efficient and convenient for use. If it be made of the form of fig. 346, the top of the funnel should have a rim ground to a flat smooth surface, over which a plate of glass may be placed to prevent evaporation. [See also figs. 186 and 187.]

In the apparatus (fig. 347), the separation of a light oil is thus effected: the oil is collected in a tube (*d*) through which the water

Fig. 345.

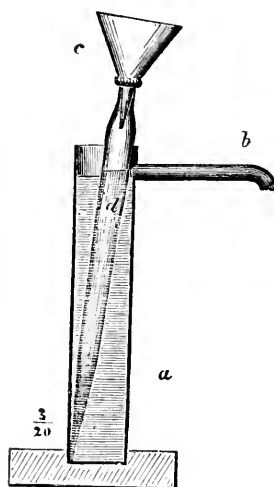


Fig. 346.



OIL-SEPARATORS.

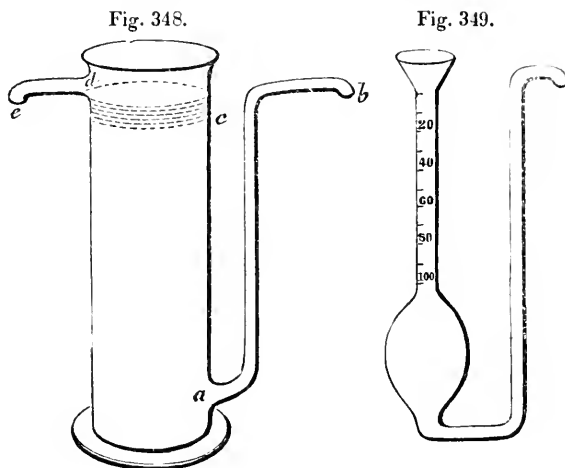
Fig. 347.



passes into the vessel (*a*); and when the distillation is concluded, the funnel (*c*) is removed, the mouth of the tube (*d*) is closed with the finger; the tube is then raised out of the vessel (*a*), and, by partially removing the finger so as slowly to admit air, the water is allowed to run out through the contracted opening at the bottom of the tube, the oil being retained by again closing the orifice at the top when the last drop of water has escaped.

[Fig. 348 represents another form of separator, capable of being used for light or heavy oils. When employed for the latter, the orifice of the tube, *b*, fig. 348, is closed until the oil that collects below rises above *a*, when it is opened, the distilled water in the meanwhile running off through the tube *d e*. On the other hand, when the oil is light, the distilled water flows off by the tube *a b*, whilst the supernatant oil may be decanted, by closing *b* until the water raises the oil sufficiently to permit it to flow off at *e*.

Fig. 349 is a separator designed to indicate the per-centage of volatile oil obtained in an experiment—the graduation being from the



top downward of course limits its use to oils that float on water. These figures are from Christison's *Materia Medica*.—W. P.]

PRESERVATION AND RECTIFICATION OF ESSENTIAL OILS.

Essential oils are very liable to undergo deterioration if long kept, and especially if they be kept in a warm place, and the vessels containing them be imperfectly closed. This deterioration arises from the absorption of oxygen, which takes place at first but slowly, but when oxidation has proceeded to a certain extent the absorption becomes more rapid. During this change they assume a yellowish or brown colour; they become less limpid; acquire a tenacious consistence, and resinous character; and, finally, are either covered over with a tough pellicle, or are entirely dried up to a substance of that kind. Meanwhile the smell undergoes a change; it becomes less characteristic of the substance from which the oil was originally obtained, and more like that of oil of turpentine. The products of this oxidation are less volatile than the oil itself, and therefore essential oils that have become partly oxidised or resinified, may be freed from the products of oxidation by submitting them to distillation or rectification.

The rectification of essential oils is best effected by putting them, together with about twenty times their volume of water, into a retort or still, and using the distilled water which passes over with the oil

for recharging the still, until the whole of the oil, excepting that retained by the water, has been drawn over.

This method of operating is found to answer better than the passing of a jet of steam through the oil. If, instead of thus distilling it with water, the oil were to be submitted to distillation alone, the quality of the product would be injured, and its character, in some cases, completely altered.

The conditions most favourable to the preservation of essential oils are, that they should be kept in a cool place, in bottles completely filled, well stopped, and excluded from the light.

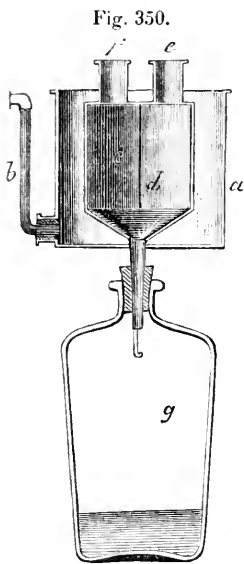
THE RECTIFICATION OF ETHER.

In rectifying commercial ether in the usual way, distilling it by the heat of a water-bath, with a retort and common condenser, it is impossible to effect the complete separation of the spirit, much of which passes over towards the latter part of the process. It is only by frequently ascertaining the specific gravity of the distilled product that the right time for stopping the process can be determined, and even then the ether distilled over will contain some alcohol, while the alcohol which remains undistilled will retain some ether. It is true that by washing the ether with water the whole of the alcohol may be removed from it, but this is an expensive method of effecting its purification, as the water thus used dissolves ether as well as alcohol, and thus renders another process of rectification necessary, unless it be thought less expensive to sacrifice the ether contained in the washing than to incur the trouble of recovering it.

This subject occupied my attention some time ago, and I contrived an apparatus by the use of which the ether may be obtained in a state of purity from the unrectified liquor in one operation, while the spirit is, at the same time, left tolerably free from ether.

The principle on which the apparatus is constructed, I have designated by a term, which may, perhaps, appear somewhat paradoxical, namely, *warm-cooling*. The vapours arising from the impure ether are conducted through a condenser which is kept constantly at a temperature of 118° Fahr., by the application of warm water. In this vessel, the temperature being some degrees higher than the boiling-point of ether, yet much lower than that of alcohol, the latter substance is condensed, while the former passes in the state of vapour into a second condenser, which is kept surrounded with cold water, and, when these can be obtained, with ice or snow.

Fig. 350 represents the *ether condenser*, which may be made of sheet tin, or, preferably, of copper. The cylindrical vessel (*a*) contains the warm water. It is open at the top, and has a tube (*b*) inserted through a cork near the bottom, by turning which the water may be drawn off, as mentioned in the description of the apparatus, fig. 263, page 264. A stop-cock might be substituted for this tube, but would be more expensive. The exit pipe of the interior vessel (*c*) passes through the bottom of the vessel (*a*). It has two openings at the top to receive the glass or tin tubes, through which the vapours are conveyed to and from this apparatus. The vessel (*c*) is divided into two compartments by the partition (*d*), so that the vapours pass down one side and up the other, and are thus more completely exposed to the influence of the warm water.

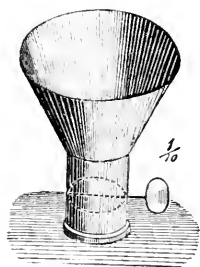


ETHER CONDENSER.

The method of conducting the process of rectification with this apparatus will be readily understood.

The crude ether, previously mixed with carbonate of potash, so as to neutralize any free acid it may contain, is put into a retort, placed in the *steam-funnel*, fig. 351, or in any other suitable apparatus for applying the heat of boiling water. The beak of the retort is connected by a glass or tin tube with the opening (*e*) of the condenser. The delivering tube of the condenser is fixed loosely in the mouth of a bottle (*g*), which is intended for the reception of the condensed spirit, and at the end of this tube there is a smaller bent tube, inserted by means of a cork, which serves to prevent the ether vapour from passing into the bottle (*g*), the drop of spirit which is always retained in the end of this tube keeping it closed. To the second opening (*f*) of the vessel (*c*), a tube is attached, by which the ether vapour is conveyed to an efficient condenser, well supplied with cold water.

Fig. 351.



STEAM-FUNNEL.

The apparatus being thus arranged, the valve of the steam-funnel, the use of which is described at pages 109 and 118, is opened, so as to admit the steam to the bottom of the

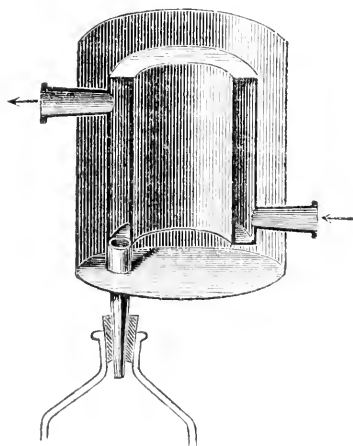
retort. At the same time the vessel (*a*) of the condenser is filled with warm water, at a temperature of 118° Fahr., and this temperature is maintained by the addition from time to time of fresh water.

When the distillation commences, ether alone will at first pass over, none of which will be condensed in the first condenser; but when the process has continued for some time spirit will begin to collect in *g*, while the quantity of ether passing into the next condenser will be diminished: and, lastly, the distillation of ether will entirely cease, and spirit alone will distil, being condensed in the first condenser, and collecting in *g*.

The ether obtained by this process has the specific gravity of pure ether. The spirit has a faint smell of aldehyde and ether. It is readily converted into strong spirit or alcohol, by distilling it from carbonate of potash or from lime.

Fig. 352 represents another form of *ether condenser*, the construction of which is similar in principle to that of *Gadde's condenser*, described at page 115. In this the vapours enter at the lower, and escape at the upper opening, as indicated by the arrows. The method of using this apparatus, and its effects, are similar to those of the preceding.

Fig. 352.



ETHER CONDENSER.

CHAPTER XII.

SUBLIMATION, TORREFACTION, DESTRUCTIVE DISTILLATION, INCINERATION, CALCINATION, FUSION, REDUCTION, AND OXYGENATION.

SUBLIMATION.

THE process of sublimation resembles that of distillation, in being generally adopted with a view to the separation of unequally volatile substances, the more volatile of which is first converted into vapour by the application of heat, and then condensed in a part of the apparatus in which it can conveniently be collected. The two processes, however, differ essentially in this, that distillation is applied to the elimination of products which are liquid, and sublimation to that of those which are solid.

Most medicinal substances which are prepared by sublimation, are invariably made on a large scale by wholesale manufacturers. Of this class are sal ammoniac, carbonate of ammonia, corrosive sublimate, cinnabar, and flowers of sulphur, which are never prepared in the pharmaceutical laboratory. Cases do occur, however, in which the pharmacist has occasion to resort to the process of sublimation, and some explanation must, therefore, be given of the apparatus to be used, and the arrangements generally adopted.

Benzoic acid and calomel are selected as substances, the preparation of which, by sublimation, will comprise those details which will be most practically useful to the pharmacist.

Sublimed benzoic acid is prepared from the resinous substance commonly called *gum benzoin*. The method formerly adopted for subliming the acid was to put the benzoin, in powder, in a Hessian crucible, and to invert a paper bag over the mouth of the crucible, while heat was applied in any suitable manner. In operating in this way, much of the acid was lost, in consequence of the vapours passing through the paper and escaping. There was also considerable loss from decomposition of the acid by the strong heat which was required to drive the

vapours through the thick cake of resin at the bottom of the crucible. The product in benzoic acid was, therefore, less than it ought to be, while an increased quantity of empyreumatic oil resulting from the decomposition by heat was at the same time formed, which tended to contaminate the sublimed acid.

Many years ago I introduced, and published an account of, a subliming apparatus, in the use of which the evils above alluded to are avoided. This apparatus has been extensively employed, and experience has established it in the estimation of practical men.

The subliming vessel consists of a shallow cast-iron pot or pan, about eight inches in diameter and two inches deep. The bottom is perfectly flat and the sides perpendicular. The benzoin, in coarse powder, is spread over the bottom of this pot to the thickness of about half an inch or rather more, and a sheet of filtering paper is then stretched over the top, and secured there by pasting it to the sides of the vessel. Over this is fitted a paper cap made of thick packing paper, joined together with paste, and standing about as high as a man's hat. The cap is secured on by tying it with strong cord.

The apparatus, thus prepared, is placed on a sheet of iron, with a layer of sand intervening, over a slow fire. The whole arrangement is represented in fig. 353. The fire should be kept up at as uniform a temperature as possible, for three or four hours, during which time the paper cap must not be allowed to become very hot, nor the vapours

Fig. 353.

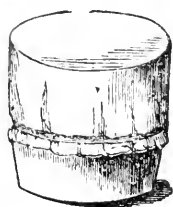
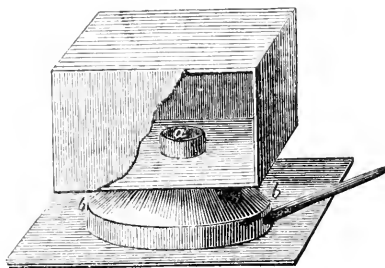


Fig. 354.



APPARATUS FOR SUBLIMING BENZOIC ACID.

to escape at the junctures. Should such occur, it would be necessary to lower the fire. Finally, the fire is to be allowed to go out, and the apparatus to cool before removing it from the stove. On untying the string and carefully raising the cap, the benzoic acid will be found in the upper part of it in large shining crystals, the groups of which are

sometimes so beautiful that it causes some regret to remove them. After taking off the bibulous paper from the top of the iron pot, the fused resin is to be cut out, coarsely powdered in a mortar, then replaced, and the apparatus fitted up as before, and submitted again to the heating process. A second crop of crystals of inferior quality will be thus obtained. Even after this, a still further product may be got by boiling the residue with lime and water, according to Scheele's method, but the properties of the precipitated acid render it unfit for use in medicine.

Fig. 354 represents a slight modification of the apparatus above described, the object here being, more completely to insure the condensation of the vapours.

In the first place, a funnel-shaped cover, made of sheet iron, is placed over the top of the pot, and fastened on with linseed-meal luting. This inverted funnel has a cylindrical top (*a*), about three inches in diameter, which fits into a square box of pasteboard or wood. A piece of fine muslin is stretched over the mouth of the cylinder, and the process, in other respects, is conducted as already described. The box, in this form of apparatus, is better protected from the heat than the paper cap in that previously noticed, the air in the space (*b b*) being constantly renewed as it becomes heated. If the box be made of wood, it may be provided with a sliding cover at the top, which will readily admit of the removal of the sublimed product. About $12\frac{1}{2}$ per cent. of benzoic acid may be obtained from the best benzoin by this process. The product obtained by precipitation is greater, but is not suitable for medicinal use.

The sublimation of calomel is a process which is frequently conducted (in Germany) in pharmaceutical laboratories. The process formerly adopted by most of those who made it for their own consumption, consisted in first rubbing together four parts of corrosive sublimate and three parts of mercury; the gray powder thus formed was then put into small glass phials in which the sublimation was effected. This method of conducting the process was, however, subject to many objections. The calomel being sublimed in a crust on to the upper part of the phials, it was necessary to break the bottles in order to remove the products. The process, therefore, involved much breakage of glass, and splinters of glass sometimes got mixed with the calomel. The product was also generally contaminated with a little uncombined mercury, and sometimes, from the cylindrical form of the subliming vessel, the ingredients, instead of being volatilized, were

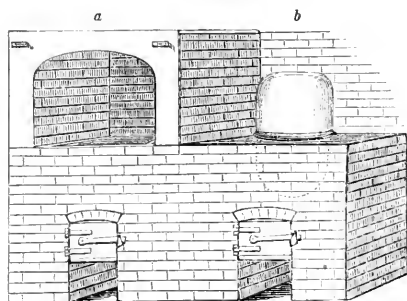
forced up in a solid mass, to the top of the phial, by the tension of the vapour formed at the bottom. Hence it became necessary, if phials were used, that they should not be perfectly cylindrical, or of equal diameters throughout their whole length.

The mixture of four parts, by weight, of corrosive sublimate, and three parts of mercury, is very nearly in equivalent proportions, the former ingredient being slightly in excess; yet on submitting the mixture to sublimation, some globules of mercury will be found in the portion that first sublimes. This result arises from the difficulty of effecting so intimate a mixture of the ingredients as to insure complete combination on the application of heat. It was customary to remedy this defect by submitting the product to repeated sublimations, until no globules of mercury could be detected.

I have proposed a modification of the foregoing process, in which the formation of the calomel is completed, before the sublimation is commenced. I use rather more than three parts of mercury to every four parts of corrosive sublimate—say thirty-one parts of the former to forty parts of the latter; these are rubbed in a mortar, with the addition from time to time of a little rectified spirit, until an impalpable gray powder is produced. Water may be substituted for spirit in this part of the process, but does not answer so well, as it is necessary that the powder should be thoroughly dried, by exposure to the air, before submitting it to the next operation. The dry powder is put into a shallow vessel, of enamelled cast iron, or Wedgwood's ware, covered with a heavy cast-iron lid, and exposed to the heat of a sand-bath. Under these circumstances the colour soon begins to change from gray to yellow as combination takes place, and this change gradually extends throughout the whole mass. At the same time, any uncombined mercury will be sublimed and condensed on to the iron cover, the heat being so regulated that it shall be sufficient to volatilize the mercury, but not the calomel. When the combination is completed, which is known from the uniform yellowish colour of the powder, the globules of mercury adhering to the cover are carefully brushed off with a feather, and collected for subsequent use; and the powder is submitted to sublimation in any convenient apparatus. One sublimation will in this case be sufficient, the product being pure calomel. If the sublimation be effected in vessels of small capacity, the calomel will be obtained in a crystalline condition, and must be reduced to an impalpable powder, by careful trituration and elutriation before being used.

[Fig. 355 represents the apparatus most frequently employed for

Fig. 355.

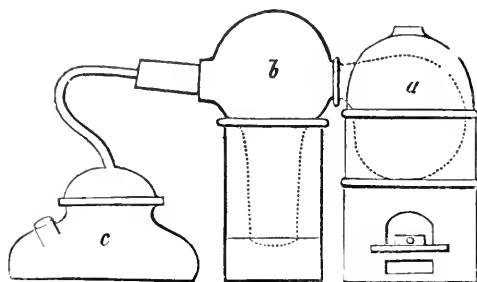


APPARATUS FOR CALOMEL AND CORROSIVE SUBLIMATE.

other (*b*), which is the subliming furnace, consists of a fire-place like *a*, over which is placed a shallow iron pot, carefully lined with clay, for containing the mixture of sulphate of mercury and common salt prepared for sublimation. Over this a stoneware head is inverted and luted around, in which the calomel or corrosive sublimate, as the case may be, is condensed. (*Pereira.*)—W. P.]

Calomel may be obtained at once in a state of minute division, by adopting the process of

Fig. 356.



HENRY'S MODIFICATION OF JEWELL'S APPARATUS FOR PREPARING CALOMEL BY STEAM.

a. Furnace containing an earthen retort having a wide short neck, in which the ingredients for preparing calomel are placed.
b. An earthen or glass receiver having three tubulures; one communicating with the retort; a second dipping into water in an earthen jar; and a third connected with a steam pipe.
c. Steam boiler.—(*Pereira, Mat. Med.*)

vessel filled with steam, by which means an impalpable powder is produced. [Fig. 356 represents Henry's apparatus.]

This process was invented by Mr. Joseph Jewell, of the firm of Howard and Company, manufacturing chemists, of Stratford, near London. There are, however, some practical difficulties in the adop-

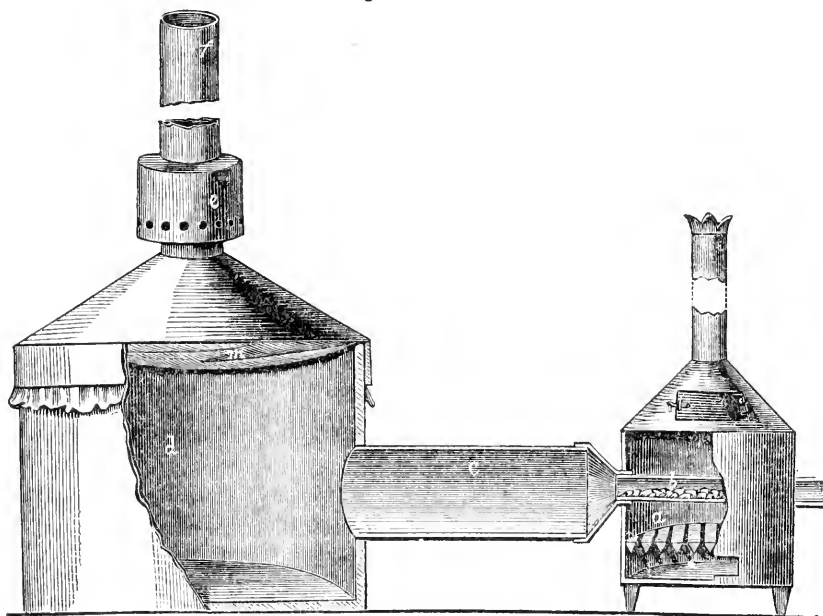
preparing calomel and corrosive sublimate. It consists of two furnaces, side by side; one (*a*) covered with a hood, under which, and immediately over the fire-place of the furnace, is a deep hemispherical iron pot, in which the mercury is converted into the bipersulphate, by boiling it with sulphuric acid; the sulphurous acid eliminated being conducted to the chimney by the hood. The

product of this process is considered to differ in its medicinal action from that obtained by sublimation. Several methods have been tried for producing sublimed calomel in a state of division similar to that of the precipitated powder. A process for this purpose has been described by Mr. Henry, of Paris, which consists in condensing the vapour of the calomel in a

tion of this process, and other means have been since discovered by which a similar result is more easily obtained.

The following process fulfils the desired object satisfactorily. The calomel is first prepared in the manner already described, by heating the mixture of corrosive sublimate and mercury until combination has been effected. It is then sublimed in the apparatus of which a representation is given in fig. 357. An earthen tube (*b*), about two inches and a quarter in diameter, and ten or twelve inches long, is

Fig. 357.



APPARATUS FOR SUBLIMING CALOMEL.

fixed across a small iron furnace. This tube should be made of a mixture of fire-clay and sand, capable of bearing the action of a dull red heat without cracking. To one end of it an earthen plug or stopper is fitted, through which passes a pipe connected with a bellows. To the other end, a tube (*c*), of much larger diameter, is attached, which communicates with a wooden box (*l*). The inside of this box is lined with glazed paper, and over the top of it a cloth (*m*) is stretched, which is secured in its place by a sheet-iron funnel, forming the top of the box. The funnel is terminated by a pipe (*f*), three or four inches in diameter, and about three feet long. Around this pipe there is a small iron corridor for the reception of ignited charcoal.

In conducting the process of sublimation with this apparatus, the

calomel is introduced into the pipe (*b*), and fires are kindled in the furnace (*a*), and the corridor (*e*). When the vapours of calomel begin to be formed, a current of air is forced through the pipe by means of a double bellows, or centrifugal blower, which mixing with the vapour, carries it into the box (*d*), while at the same time the vapour is condensed and its further progress is arrested by the cloth (*m*). When the tube (*f*) gets well heated, there may be sufficient draught without using the bellows, in which case the plug must be removed from the mouth of the tube (*b*), and the process can then be maintained uninterruptedly for a great length of time, fresh portions of the powder being introduced into the tube as the sublimation proceeds.

It is not necessary in this process to have a current of air passing through the apparatus, provided that the vessel or chamber into which the vapours are conducted be of ample size, so that by the admixture of a large quantity of cool air condensation may be speedily arrested. In fact, the condition of the products obtained by sublimation, are always influenced by the size and position of the receiver in which the vapours are condensed. If the receiver be small, and if it be immediately contiguous to the vessel from which the substance is sublimed, the product will assume a crystalline condition, the temperature being such as to admit of the slow and regular aggregation of the particles. If, on the other hand, the receiver be large, or if from its position the air within it be kept cool, the sublimed product will assume a more or less amorphous condition, the condensation being so rapid that no symmetrical arrangement of the particles can take place.

TORREFACTION.—When organic substances are exposed to a degree of heat capable of modifying certain of their constituents, and thereby developing new properties, or destroying previously existing ones, the process is called *torrefaction*.

[Metallic arsenic is obtained for medical purposes by heating equal weights of arsenious acid and black flux, in a large glass tube, protected by one of iron, to dull redness. The alkali of the flux is important. The metal condenses in the upper part of the tube as a brilliant sublimate.—W. P.]

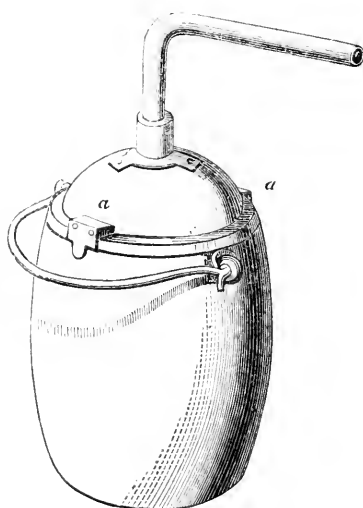
When rhubarb is thus heated, its cathartic power is nearly destroyed, whilst its astringent quality is unimpaired. The operation is performed in shallow iron vessels, placed on a sand-bath strongly heated, or at such a distance above a direct source of heat, that the temperature can be regulated. In torrefying rhubarb the root should be in a granular powder, and well dried: it is less liable to adhere to the surface of the dish. The stirring requires to be constant, and so regulated that the whole of the powder will be acted on by the

heat and acquire a uniform change of colour. The burning of coffee, for culinary purposes, is a familiar instance of torrefaction. Oily seeds were formerly torrefied previously to extracting their fixed oil by expression or boiling; starch is now converted into British gum and dextrine, on a large scale in the arts, by this process; and certain vegetable acids, as citric, malic, and tannic acids, are converted into other acids.

DESTRUCTIVE DISTILLATION.—When dry organic matter is placed in a distillatory apparatus, and heat applied until all volatile matter is driven over, the process is called *destructive distillation* when viewed in reference to the distillate, and *carbonization* in relation to the fixed residue.—W. P.]

The process of *dry*, or *destructive distillation* is but seldom performed in the pharmaceutical laboratory, for although several substances in the preparation of which this process is applied, such as *acetic acid*, *oil of amber*, *succinic acid*, and *acetone* or *pyroacetic spirit*, are used in medicine, yet these are usually made exclusively by the wholesale manufacturer. The pharmacist, however, is sometimes required to perform processes of this kind, and on such occasions may experience difficulty in determining the best method of effecting the desired object. The substances operated upon in these processes are generally solid; the heat applied to them is much greater than that employed in ordinary cases of distillation; and the residuums left in the distillatory vessels, being usually in a fused, compact state, firmly adhering to the vessel, and insoluble in water, can only be removed by mechanical means. It is, therefore, necessary to employ apparatus of a peculiar description applicable to these conditions. *Glass* vessels are not generally suitable; they do not bear the required heat without cracking, or fusing, at least, when made of common English glass, and the residuums cannot be removed without breaking the apparatus. *Earthenware* or *porcelain* vessels are sometimes used, but these do not answer well, unless made of the best porcelain, which is expensive. *Cast iron* is the material of which the

Fig. 358.



APPARATUS FOR DRY OR DESTRUCTIVE DISTILLATION.

apparatus used in these processes, or at least, that part of it which is exposed to the fire, is usually made, and this is in every respect well adapted for the purpose, being economical, and sufficiently infusible when carefully used.

These processes are not of sufficiently frequent occurrence to require the provision of apparatus in anticipation of them; and, when they do occur, they are generally not of sufficient importance to justify the expense of having a suitable vessel cast expressly for the purpose. I have found a small cast-iron boiler, commonly called a *Papin's digester*, easily convertible into an apparatus suitable for dry distillation. These *digesters* are sold by all ironmongers, and the only alteration required to adapt them for the use here contemplated, consists in removing the safety-valve from the top of the cover, and fixing in its place a bent iron tube, as shown in fig. 358. The cover fits on to the boiler with a steam-tight joint, and is kept securely in its place, when in use, by the clamps (*a a*).

[INCINERATION.—When, instead of conducting the heating process in distillatory arrangements, the organic matter is heated to redness in open vessels until all the carbon is consumed, the process is called *incineration*, and has reference, as its name implies, to the fixed residue or ashes. As contact of air is necessary to oxidize and remove the carbon, stirring is necessary to expose all parts of the matter to the action of the air.

The essential salt of wormwood (carbonate of potash) and of other plants of old pharmacy required this process; the researches relative to the inorganic matter of plants and animals require its aid; and the incineration of land and marine plants is extensively conducted in the manufacture of potash, barilla, and iodine. The process of making *bone-earth*, or bone phosphate of lime, so largely employed in the manufacture of phosphorus, phosphoric acid, and the phosphates of ammonia and soda, is another instance of its application in pharmaceutical chemistry.

CALCINATION.—Calcination differs from incineration chiefly in being applicable to mineral or inorganic compound substances. It has several objects:—1st. To deprive a compound of some volatile ingredient, as the carbonates of magnesia, lime, and oxide of zinc, of their carbonic acid; alum and gypsum of their water of crystallization; and the nitrates of copper and mercury of their nitric acid, to isolate their oxides. And 2d, to expose a metal or a mixture to heat and air, either to produce direct oxidation, as in making litharge, red lead, and flowers of zinc, or to desulphurate certain sulphurets, at the

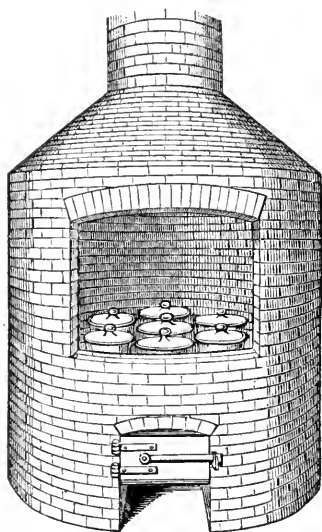
same time that their metallic base is oxidized; in which cases the process is often called *roasting*. This mode of oxidizing is effected by the action of the flame, the products of combustion and heated air yielding the necessary oxygen, and hence the process on a large scale requires to be conducted in a reverberatory furnace. Arseniuret of cobalt yields zaffre as a fixed, and arsenious acid as a volatile, product by this process of oxidation.

When a mineral substance capable of combustion by heat alone, or when associated with other substances capable of yielding oxygen, is thrown on a red-hot surface, as in a heated crucible, the process of oxidation is called *deflagration*. The pure carbonate of potassa (white flux) of the Pharmacopœia, is thus made by igniting a mixture of cream of tartar and nitre; the *crocus of antimony*, used in making tartar emetic, is the result of deflagrating a mixture of sulphuret of antimony and nitre; and antimonial powder is made by deflagrating horn shavings and sulphuret of antimony together, and subsequently exposing the calcareous antimonial residue to intense heat.

The process of calcination is applied extensively to the preparation of magnesia for pharmaceutical purposes. Fig. 359 represents the kind of furnace used in England for effecting it, which is constructed like a potter's kiln. The hydrated carbonate of magnesia, the ordinary light carbonate, is packed in deep unglazed, crucible-shaped, earthen pots, with covers fitting loosely, as seen in the figure. The fuel best adapted for this purpose is coke. The vessels are arranged above the fire on suitable supports, and are kept at a full red heat for several hours. It is not necessary to carry the heat beyond the degree indicated by full red: if less than this, there is danger of a part of the carbonate escaping decomposition. On the contrary, if the temperature is advanced to a white heat, the product is apt to be lumpy.

Dense calcined magnesia is made by precipitating a heavy carbonate of magnesia from concentrated solutions of carbonate of soda, and

Fig. 359.



FURNACE FOR CALCINING MAGNESIA.

sulphate of magnesia, evaporating the mixture to dryness, calcining the dried mass of carbonate of magnesia and sulphate of soda, until the carbonic acid is all extricated, washing the cold residue until all the soluble saline matter is removed, and finally drying the remaining magnesia at a moderate temperature. (Pereira.) The calcination of magnesia is sometimes effected, by packing the carbonates, as stated above, in earthen vessels, and placing them in a potter's kiln during the time required to burn the pottery.

FUSION.—When fixed solid bodies are subjected to sufficient heat, they assume a fluid state, and are said to *fuse*, *melt*, or *liquefy*, and the process is called *fusion*, and sometimes liquefaction. No other known cause besides heat will produce this effect, but the temperature necessary for the fusion of different bodies varies exceedingly. Fusion in the pharmaceutical laboratory is usually performed in crucibles, (see page 78,) and the material and size are chosen to suit the particular object in view. The precautions to be observed in heating crucibles, and in reference to those of platinum, have been already noticed. For the fusion of zinc and tin for granulation, for the preparation of fusible metal, sulphuret of iron, &c., the Hessian crucible answers every purpose; but where its roughness and penetrability are objectionable, Wedgwood-ware affords a better means, as in fusing iodide of potassium, nitrate of silver, chloride of zinc, &c. Where iron crucibles can be employed in fusion, they are greatly preferable, as they are not liable to crack. They are used in making iodide of potassium, common caustic potash, cyanide of potassium, and sal prunel.

When pure caustic potash or soda, and nitrate of silver, are to be fused and cast in sticks, the silver crucible possesses many advantages.

REDUCTION.—When metallic oxides, chlorides, sulphurets, &c., heated alone, or admixed with other substances, are reduced to the metallic state, whilst the combined body is either volatilized or enters into combination with the admixed substance, the process is called *reduction*.

The oxides of the noble metals are reduced by heat alone, but the others require fluxes and carbon. In the manufacture of iron, the reduction is effected by the carbon of the charcoal or coal, whilst the lime used as a flux forms slag with the silicious and aluminous matter associated with the ferruginous oxide in the ore. Fluxes are used in the purification of certain metals, as when saltpetre is heated with alloyed gold and silver, to oxidize the baser metals, and separate with them as dross. Borax, boracic acid, phosphate of soda, bisulphate of

potash, lime, and flint glass, are also used as fluxes. Carbonate of soda, heated with chloride of silver, acts as an agent of reduction, by becoming chloride of sodium, the silver separating by fusion, as a button, at the bottom of the crucible. Hydrogen is one of the best reducing agents, but its application requires certain special arrangements. The method of reduction by hydrogen will be treated of in the chapter on the GENERATION AND ABSORPTION OF GASES.

OXYGENATION OR OXIDATION.—By the term *oxidation*, in reference to pharmaceutical operations, is understood, the addition of oxygen to a substance, to raise its degree of oxidizement if an oxide, or to form an oxide from a free element.

Oxidation is effected in the wet way, by treating the substance in solution, with nitric or chromic acid, or with a mixture of binoxide of manganese and sulphuric acid, in either of which cases, oxygen in a nascent condition is yielded to the substance:—or it is accomplished in the dry way by combustion. The process of roasting, already instanced, is an example of this mode of oxidation.

Of the first way, the conversion of protoxide into peroxide of iron, will afford an illustration as required in the Pharmacopœia, for obtaining the ter-sesquisulphate of iron, employed in the formulæ for hydrated sesquioxide, and ferrocyanuret of iron. A solution of the protosulphate in water is made, half an equivalent of sulphuric acid is added to it, (that is to say, half as much as the sulphate already contains,) the solution is boiled, and then by successive additions, nitric acid is added, until the evolution of red fumes ceases to be observed. The solution is then boiled, to free it from nitric oxide gas, and if it does not produce a blue precipitate with red prussiate of potash, the oxidation is completed.

Phosphorus is converted into phosphoric acid by boiling it with nitric acid, the operation being performed in a distillatory apparatus, so that the undecomposed nitric acid that vaporizes may be returned to the retort.

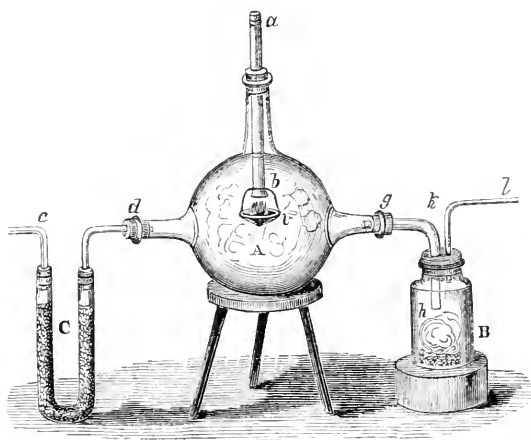
A mixture of bichromate of potash and sulphuric acid is generally employed when organic substances are to be operated on, as in these, nitric acid will often induce changes not desired.

When combustion is resorted to, certain arrangements are required to collect the oxide formed. When zinc is thus treated to produce flowers of zinc, the metal is heated strongly in a shallow iron vessel, over a furnace, placed alongside of a suitable chamber for collecting the oxide, which, though not volatile, is mechanically carried off by a current of air. A hood is placed over the red-hot zinc, opening into

the chamber, and a current of air determined into the chamber through the hood, and over the surface of the zinc, by forming a communication between the back of the chamber and a good draught chimney. A partition of gauze should be placed across the rear of the chamber, to prevent the flocks of oxide from being carried up the chimney.

Anhydrous phosphoric acid, for dental and other purposes, may be prepared on a small scale by igniting a drachm of phosphorus, placed on a capsule, and immediately inverting over it a large, perfectly dry, earthen jar. The acid collects on the sides of the jar. Professor Graham has described an arrangement by which the anhydrous acid can be obtained in quantity. Fig. 360 represents this apparatus. "The phosphorus is burned within a large glass balloon, A, having

Fig. 360.



APPARATUS FOR PREPARING PHOSPHORIC ACID.

three tubulures, which has been well dried beforehand. The cork of the upper tubulure is traversed by a long tube, *a b*, open at both ends, and about half an inch in diameter, and which descends to about the centre of the globe. A little capsule of platinum or porcelain, *v*, is attached by means of platinum wires below the lower opening of this tube. To the second tubulure, *d*, a drying-tube, C, containing pumice soaked in oil of vitriol, is attached; and to the third tubulure, *g*, a somewhat wide bent tube, *g h*, of which the other extremity descends into a well-dried bottle, B. This last vessel is placed in communication, by means of the tube *k l*, with any aspirating apparatus, by

means of which a continuous current of air is determined, which penetrates by the tube C, where it is dried, and traverses the whole apparatus. A fragment of phosphorus is now dropped on the capsule, *v*, by the tube *a b*, lighted by a hot wire, and the upper opening, *a*, closed by a cork. When the combustion is completed, another fragment of phosphorus is added, always taking care to dry the fragment carefully with filter paper before introduction. The phosphoric acid produced is partly deposited in the globe, A, and partly carried forwards to the bottle B;" and the process may be continued until the quantity produced is sufficient.

CRYSTALLIZATION.—A large number of chemical substances, in passing from a fluid or vaporous to a solid state, assume certain determinate forms, which are bounded by surfaces of mathematical outline, and these surfaces and forms are among the most reliable characters for distinguishing these substances. The philosophy of crystallization does not come within the scope of a practical treatise; the subject will be viewed in reference to the best methods and directions for obtaining substances in crystals, to improve their appearance, or as a means of their purification.

As a general rule, it is necessary that bodies be in a fluid or gaseous state to enable the particles to obey the laws of crystallization, but in a few instances the change occurs without loss of solidity, as in barley-sugar, iron and brass wire, &c.

There are several methods of obtaining crystals. By sublimation, by fusion and partial cooling, by deposition from supersaturated solutions as they cool, by deposition from solutions as evaporation proceeds, by precipitation, or by deposition from a solution through the agency of a voltaic current.

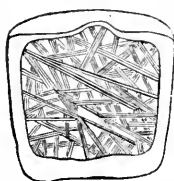
1st. Sublimation is only applicable to volatile solids, as benzoic acid, calomel, corrosive sublimate, iodide of arsenic, and biniodide of mercury. A number of organic principles are obtained in crystals by this process, but with the exception of some of those mentioned, this method is rarely resorted to as a means of crystallization.

The more slowly the vaporization is effected, the larger and finer are the crystals. When rapid, the sublimate forms a solid crystalline mass, as carbonate of ammonia.

2d. The process by fusion and partial cooling, includes some of the metals, sulphur, and other substances, which have low fusing points. The substance is fused in a rather deep vessel, as a crucible, and in cooling, as soon as a crust has formed on the surface, a small aperture is broken through it on one side, and a larger on the other. The vessel

or crucible is now canted towards the side next to the larger hole, and the fluid contents poured out from the interior. The sides and bottom of the vessel, and the under side of the crust, will be studded with crystals, which are large and well defined in proportion to the quantity of fused matter, the gradual cooling to which it has been subjected, and the dexterity of the manipulator in rupturing the crust and decanting the contents, for the more rapidly the

Fig. 361.



latter is effected, the sharper and better defined will the crystals be. Fig. 361 exhibits the crystallization of sulphur as effected by this process.

3d. The most usual process is to make a solution of the substance, saturated at a temperature above that of the air, and suffer it to cool gradually. In the chapter on the methods of solution, the manner of obtaining saturated solutions was explained. Crystallization in this way is, therefore, the direct reverse of solution.

The degree of concentration proper for solutions intended for crystallizing, depends on the solubility of the substance. When very soluble, the solution should not be saturated at the boiling temperature, if it is desired to obtain well-defined crystals. Acetate of zinc is an instance of this. The evaporation of the dilute solution should be continued until a drop of the liquid removed to a plate of glass, deposits transparent well-defined hexagonal plates from a transparent mother-water. The abundance of these in proportion to the amount of liquid, will govern the operator as to the extent of the concentration. In the manipulation of large laboratories it is found more certain to employ the hydrometer for salts. Experience having taught the specific gravity of a solution proper for crystallization of each substance, all that is necessary is to evaporate until the instrument indicates the required density.

Having obtained the solution, the next steps are to place it in a situation where it will not be disturbed, and to regulate the cooling. The more slowly and uniformly the cooling, and consequent deposition of the particles is, the larger and more regular will be the crystals formed. Sometimes the vessel is placed in the drying-closet, and suffered to cool with it; sometimes the vessel is allowed to remain in the sand-bath after the fire has been put out, so as to cool with the sand; but more frequently it is merely set aside, where it will not be disturbed, covered with a plate of glass, or another vessel, to prevent evaporation, and to protect the solution from contamination by dust. After crystallization has commenced, the vessel should not be removed,

or the solution agitated, else the order of deposition will be changed, and new crystallizations will commence on the surfaces of the crystals first formed. In small operations, it is often proper to envelope the covered vessel in several folds of a woollen cloth, to retard the cooling.

When the substance treated is not very soluble, the solution should be evaporated until a pellicle forms, and then be set aside and covered. Crystallization is frequently much facilitated, by placing nuclei of some kind in the solution, which form starting-points for the process; strings, wire, pieces of wood, sheet lead, &c., are used, as the case may be. Tartar emetic is thus obtained on wire in beautiful columns. Blue vitriol and prussiate of potash are also thus crystallized on billets of wood. In the copperas manufactories, it is usual to suspend strips of sheet lead in the crystallizing vats, to obtain regular crystals for sale as "sulphate of iron." Strings are placed transversely across the jars in which sugar candy is crystallized with the same intent.

In small quantities, the nucleus may be a crystal of the same substance; and a mass of crystals may be removed from an exhausted crystallizer, and suspended in one just charged, so as to receive a fresh deposit. With dexterity, very large crystals may be formed in this manner.

When it is desirable to have the substance in small crystals, to facilitate its solution, as in the case of Epsom salts, or for some other reason, the hot saturated liquid is kept in constant agitation during the cooling process, which effectually prevents the aggregation of large masses.

However obtained, the liquid from which a crop of crystals has been deposited, is called the *mother-water*. This may be a pure solution of the salt deposited, or it may consist of a cold saturated solution of this, containing other salts. It is owing to this power or ability of a saturated solution of one substance to dissolve others, that crystallization is so valuable a means of purifying crystallizable bodies. This fact has been illustrated at page 236, and is now applied in a converse manner. Carbonate of soda is thus freed from admixed sulphate, and the kelp liquor, containing the iodides and bromides derived from the ashes of marine plants, is the mother-liquor of carbonate of soda. In the crystallization of organic principles, sugar, mucilage, extractive matter, and other substances, often greatly interfere with the separation of the crystals, sugar especially. The solution may be freed from gum by hydrated oxide of lead, and fermentation is resorted to in some cases to destroy uncrystallizable sugar. When a different menstruum, as alcohol, will dissolve the body sought,

and reject a part or all of the associated matters, they may be avoided by this means. The decolorizing effect of animal charcoal, by removing colouring and other matter from solution, also promotes the formation of crystals, and has to be repeatedly resorted to in the preparation of many organic bodies, as vegetable acids, alkalies, and neutral principles. In making caffen by the ordinary process, the power of crystallization to purify, is beautifully illustrated. The mother-water is a dense, syrupy, dark-coloured liquid, whilst the crystals of caffen assume the aspect of bundles of white silky fibres, after being drained.

Isomorphism, or the assumption of the same crystalline form by different bodies, which have a similar atomic constitution, presents a difficulty in certain cases to the purification of these bodies by crystallization. Owing to this cause, sulphate of zinc cannot readily be freed from sulphate of protoxide of iron, or protosulphate of manganese from the same salt. In these instances, the contaminating salt is best removed by boiling the solutions with a portion of pure hydrated carbonate of the base of the salt to be purified, until the protoxide of iron is displaced and peroxidized, when the excess of carbonate, and the oxide of iron, are removed by filtration. Acetate of zinc is most readily purified in this manner.

Very soluble substances, as citrate and carbonate of potassa, iodide of iron, chloride of calcium, iodide of zinc, &c., cannot be obtained in good crystals, unless large quantities of the salts be treated. Sometimes, as in the two first-named substances, the evaporation is continued to dryness, the salt separating in granular crystals. When this process is to be executed, as soon as the quantity of salt separated is so great as to present an obstacle to the ready liberation of the vapour, and to cause adhesion to the bottom of the vessel, the stirring process should be commenced, and continued constantly until the granulation is completed. This process requires more attention to the source of heat, when salts of organic acids are treated, than when they are mineral.

There are certain salts which do not crystallize, but which dry in a transparent amorphous mass by evaporation, as, for instance, the citrate and tartrate of sesquioxide of iron. The solutions of these should be evaporated to a syrupy consistence, and spread by means of a soft flat varnish-brush over the surface of plates of glass. As the moisture evaporates, the salts are obtained in brilliant transparent scales. The solutions should be perfectly transparent, and the glass dry and free from finger-marks, and as flat as possible.

As has been stated, the *mother-water* may be a pure, or an impure,

solution of the crystals obtained;—if the first, it only needs a further evaporation to get a new crop of crystals; when impure, it is also evaporated and crystallized, the second crop of crystals being thrown on a cloth and drained, or washed with a solution of the pure salt, and then, if not pure enough, are recrystallized. When the chief impurity is colouring matter, the mother-water is decolorized with animal charcoal, and then again crystallized.

The vessels in which crystallization is effected should be deep. Stoneware basins, called crystallizers, are made for this use, and they are most convenient when arranged with a lip to facilitate the decantation of the mother-liquid. When the inner surface is rough, the formation of crystals is facilitated. For small operations, ordinary capsules, or those of Berlin-ware, answer very well.

Sometimes substances, insoluble in any simple menstruum, are dissolved by, and deposited in crystals from, certain saline solutions. Biniodide of mercury is thus obtained in beautiful prisms by employing a solution of common salt, iodide of potassium, or pernitrate of mercury. This is called *intermediate* crystallization.

Morphia, meconic, benzoic, and salicylic acids, are instances of substances that precipitate in crystals in the act of separation from their solution by chemical reaction; but this is not adopted as a means of getting fine crystals: the aggregation is too rapid to allow of the gradual superposition of crystalline strata.

It only remains to state that M. Becquerel has shown that the action of weak voltaic currents, long continued, is the probable cause of the beautiful crystallizations of many minerals; and he has obtained red oxide of copper, and other substances, in crystals, artificially, by this means.

PRECIPITATION.—When a substance, or its elements, existing in solution, suddenly loses its soluble form, and separates from the liquid in a minute state of division, by the addition of another solution, which may or may not contribute to the separated substance, the latter is called a *precipitate*, the added substance, or liquid, a *precipitant*, and the act itself *precipitation*.

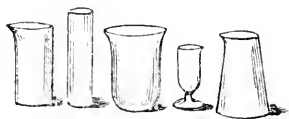
Precipitation is *simple*, when the separation is due to a physical change in the menstruum, as when albumen is precipitated by heat, when kermes separates by cooling, when salts are precipitated by alcohol from their watery solutions, or resins from alcohol by water. And *complex*, when the precipitant produces a chemical change in the solution, either by combining with the dissolved substance, and precipitating with it, as when sulphuric acid is added to baryta water, or oxalic

acid to lime-water; or by combining with one ingredient of a compound, whilst the other is separated, as when sesquichloride of antimony, and nitrate of bismuth, are precipitated by water, or sesquisulphate of iron by ammonia. The precipitation of silver by mercury, lead by zinc, in the process of the U. S. P. for making acetate of zinc, and of copper by iron, are instances where the *precipitant* is employed in a solid form, and replaces the precipitated substance in the solution.

The most usual cases of precipitation, however, are those of double decomposition between the solutions of two soluble salts. Precipitation is employed in pharmacy as a means of pulverization, as a means of purification, and as the most convenient method of obtaining many insoluble substances.

Vessels for precipitating should be larger at bottom than top, or at least cylindrical, so that their sides will oppose no hindrance to the free subsidence of the precipitate. Fig. 362 represents several forms

Fig. 362.



of precipitating glasses that are used for small operations. The precipitate, by occupying less height in the vessel, admits of a larger quantity of liquid being drawn off by decantation. In preparing large quantities of proto-

carbonate of iron, for Vallet's pill mass, or of sesquioxide of iron for saline combinations, deep wooden tubs, shaped like a churn, are most convenient. When very large, they may be provided with several orifices, at different heights, along the side, to facilitate the decantation of the washing liquid.

When the two solutions for precipitation contain the proper quantities for mutual decomposition, no care is to be observed, in most instances, in what manner the precipitant is added; but when the proportion is not known, the latter is to be added until it ceases to produce a separation in the other liquid. When the solutions operated on are dense, and the precipitate bulky, the subsidence of the latter is too slow for the operator to wait until sufficient supernatant liquid is exposed, before making the addition. In these cases, after thoroughly stirring the magma, (and in doing this the stirrer should be so managed as to bring the bottom portions to the top by a lifting motion,) a little should be removed to a small paper filter, the edges of which are gathered between the fingers and thumb, and gently expressed, until a few drops, or a fluid drachm, of the clear liquid has passed, when the addition of a drop of the precipitant to this, decides the question. A little practice renders this apparently tedious method, easy and rapid.

In small operations, as in testing the strength of hydrocyanic acid with nitrate of silver, or in isolating organic acids from their insoluble salts by the addition of mineral acids, the addition of the precipitant requires the greatest care to avoid an excess.

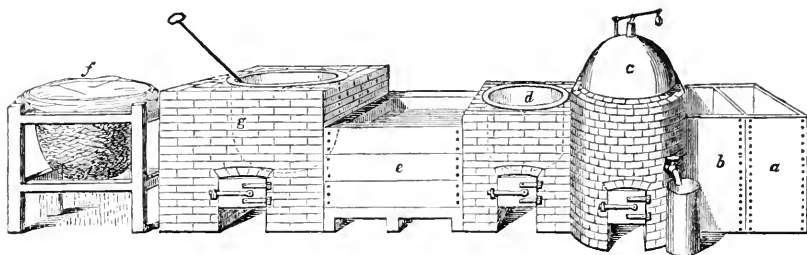
When ammonia is used as the precipitant, its odour is the best criterion to guide the operator in its addition. This renders it extremely valuable in the process for making hydrated sesquioxide of iron, for antidotal purposes, where the utmost celerity in manipulation is required. The pharmacist should feel himself obligated to keep constantly at hand a concentrated solution of sesquisulphate, or sesquichloride, of iron, with a view to furnishing this valuable remedy at a few minutes' warning. The careful washing of the precipitate, so necessary and proper when the oxide is designed for combination, or other chemical purposes, is to be avoided in this case, as the time required to perform it is too great. The concentrated solution, each fluid ounce of which may contain fifty grains of the oxide, is poured in a suitable vessel, ammonia is added in *slight* excess, stirring the mixture during the precipitation, and the whole thrown on a flannel cloth, and expressed with the hand until the excess of water, holding in solution sulphate or hydrochlorate of ammonia, has been separated. The pasty oxide is then diluted with water till of the consistence of thick cream, and is ready for use. In the course of some experience in the preparation of sesquioxide of iron as an antidote, in which a number of lives have been saved through its agency, no ill effects have resulted from the presence of small quantities of ammoniacal salts. A skilful manipulator can readily prepare the antidote in *ten minutes* from the time of its demand.

As a general rule, dense solutions yield dense precipitates, and the denser the precipitate the more easily is it washed. These facts are worthy of note in the preparation of protocarbonate of iron for Vallet's pill mass. The quantities of liquid directed in the Pharmacopœia are inconveniently large, and in preparing considerable quantities of the salt, the size of the vessels would present a formidable objection to following the directions to the letter. A dense precipitate, by subsiding rapidly, admits of being washed by the process of decantation with greater facility.

The influence of this fact is taken advantage of in preparing *heavy carbonate of magnesia*. Fig. 363 (for which we are indebted to Pereira) exhibits the arrangement employed at Apothecaries' Hall, London, for making the heavy carbonate: *a* is a cistern for dissolving the sulphate of magnesia; *b*, another cistern for effecting the solution

of the carbonate of soda; *c*, a boiler for supplying hot water; *d*, another boiler for boiling the mixed solutions; *e*, a vat or back in

Fig. 363.



APPARATUS FOR PREPARING HEAVY CARBONATE OF MAGNESIA.

which the carbonate is allowed to settle, and in which it is partly washed by decantation; *f*, a linen strainer, placed in a wicker-basket supported by a wooden stand; and *g*, an iron pot over a fire-place for drying the carbonate.

To prepare this form of carbonate of magnesia, one volume of a cold saturated solution of sulphate of magnesia, diluted with three volumes of water, is mixed with one volume of a cold saturated solution of carbonate of soda in the boiler (*d*), wherein they are boiled with constant stirring until effervescence ceases. The whole is then transferred to the vat (*e*), wherein it is partially washed, and then to the filter (*f*), where this process is concluded. It is finally transferred to the vessel (*g*), to be dried. When either this, or the common carbonate is wanted in the form of squares, the drained precipitate, in a soft state, is transferred to square moulds, like those used for bricks, without bottoms, and placed on an absorbent surface. As soon as the magnesia acquires sufficient consistence to be removed from the moulds, it is placed on hurdles covered with paper, in a drying-room, until completely deprived of moisture.

In some cases, where two solutions are employed for producing a precipitate, it is *not* indifferent which of them is the precipitant. When ferrocyanide of potassium and sesquisulphate of iron are used for making Prussian blue, the ferrocyanide solution should be added to the sulphate solution, else if the contrary order is pursued, a soluble green compound containing the ferrocyanide will be simultaneously formed.

The washing of precipitates is a very important part of their management, and has been treated of at pages 191 and 206. When admissible, washing by decantation and subsidence should be resorted to

at first, and subsequent draining and displacement, with pure water on a filter, follow it.

NEUTRALIZATION.—Neutralization is a term that applies in a chemical sense only to *acids* and *bases*, and indicates their condition when certain properties characteristic of them are mutually destroyed by their combining with each other.

Acids, and soluble bases, affect certain colours in particular ways, with different intensities; and paper tinted with these colours is called test paper.

The most usual colouring matters for ascertaining the neutrality of solutions, are *litmus*, *turmeric*, and infusion of *red cabbage*. Litmus is employed in the form of a tincture in diluted alcohol, and as an infusion in water, when it is desirable to employ it in the liquid form; but the most usual and convenient method of applying it is in the form of tinted paper. Litmus paper is prepared by triturating the colouring matter with hot water, in the proportion of one part to eight of water, infusing for an hour or two, and decanting the clear solution. The dregs will yield more colour, which is extracted in the same manner, but the intensity of the colour is not great enough until it is concentrated. The paper, which should be unsized, or filtering paper, and free from alkaline or acid matter, is saturated with this infusion, and hung across strings to dry, in an atmosphere free from acid or ammoniacal vapours. Blue litmus paper is reddened by acids, and it is a test for acidity. When litmus paper is thus reddened, it affords a delicate test for alkalies, which restore its blue colour.

Turmeric paper is prepared in the same manner, with the exception that the bruised turmeric is boiled for half an hour, and the clear decoction used to tint the papers, which have a uniform bright yellow hue. Turmeric paper is turned reddish-brown by alkaline solutions.

An acid infusion of red cabbage, which, like litmus, may be employed for acids or alkalies, is prepared in the following manner. The red cabbage is sliced, placed in a porcelain capsule, and sufficient dilute sulphuric acid poured over to cover it. The acid should be in the relation of half an ounce to each cabbage, according to Faraday, but its proportion is not very important. The whole should then be heated nearly to ebullition, and suffered to stand until it cool. The clear infusion is decanted, concentrated to one half its original bulk, and after standing until clear, is decanted and preserved in close bottles for use. When employed as a test, the acid is neutralized carefully with a fixed alkali, potash or soda, which causes it to assume a deep blue colour; but it should only be thus prepared at intervals when

wanted for use, as the acid is necessary to preserve the solution from decomposition. Blue cabbage liquid is turned red by acids, and green by alkalies, and hence has the advantage over either of the other tests by deciding the neutral condition of a liquid by the tint it assumes. Paper may also be tinted with red cabbage.

Test paper should be cut in narrow strips, and each kind kept in its appropriate wide-mouthed bottle, be kept well corked from the air, especially in the shop and laboratory, where acid and alkaline fumes are frequently existing.

In using test papers, the paper may be dipped in the liquid to be examined, or if this may possibly be contaminated by the paper, a drop of the liquid is removed to the paper by a glass rod. As the solution approaches neutrality, the change in the red or brown tint, as the case may be, becomes less and less intense, until it ceases to change the colour. In employing litmus in neutralizing acids, an excess of alkali is not indicated by the paper, and hence the utmost care is required to stop at the right point, or else reddened litmus paper should also be used, which will give an alkaline indication. In analytical investigations, where the operator is compelled to extreme accuracy, the operation should only be performed by daylight, and the effect of merely moistening the paper with pure water should be noticed at the same time. It is difficult to ascertain the neutral condition of dense solutions, as for instance, in preparing citrate of potassa, where the smallest proportion of water is used to save evaporation. In such cases a drop of the solution should be diluted, and then the test applied. It is also best to heat the solution, especially where carbonic acid gas is eliminated, as it renders the liquid more mobile, and frees it from the absorbed gas.

Alkalimetry, and *acidimetry*, are processes for ascertaining the proportion of free alkali, or alkaline carbonates, on the one hand, or free acid on the other, which exist in any sample of potash, soda, or ammonia, for instance, in the first case, or of sulphuric, acetic, or other acids, in the second.

The process of alkalimetry involves two distinct operations; *firstly*, the preparation of a dilute sulphuric acid, that contains one hundred grains of anhydrous sulphuric acid in one thousand grain measures of the liquid,—that is, in the space occupied by one thousand grains of distilled water. As the oil of vitriol of commerce varies in strength, it is best not to depend on its specific gravity, but to ascertain its real value by saturating 100 grains with anhydrous carbonate of soda, made by heating the pure bicarbonate to dull redness. Every 53·27

grains, or one equivalent, of the carbonate, corresponds to 40.09 grains of real sulphuric acid; consequently the amount of real acid in the hundred grains of oil of vitriol is readily arrived at by the rule of proportion. Suppose the acid required 108 grains of carbonate, then:— $53.27 : 40.09 :: 108 \cdot \cdot 81.3$.

It follows that such oil of vitriol contains 81.3 per cent. of anhydrous acid. Now as it is most convenient to prepare more of this test acid than will be used for one occasion, the operator will proceed as follows. Suppose that he wishes to prepare a measure equal to ten avoirdupois pounds of water, or one imperial gallon, which is the same, viz., 70,000 grains, requiring 7000 grains of anhydrous acid. Then, as

$$81.3 : 100 :: 7000 \cdot \cdot 8610.$$

8610 grains of the oil of vitriol in question therefore represents 7000 of real acid. He will therefore take a suitable bottle, weigh ten pounds (av.) of pure water into it, and mark the level of the liquid carefully. He will then pour out about one-third of the water, weigh 8610 grains of the oil of vitriol tested, mix it gradually with the water in the bottle, and then add sufficient water to fill the bottle to the level mark. If the temperature of the liquid should be warm, allow it to cool to 62° Fahr., and then add sufficient water to complete the measure, if the liquid diminishes perceptibly in volume.

The *second* step in the process is the use of the alkalimeter. This is a graduated tubular glass, (fig. 364,) with a foot-stand below and lip above. It should be ten or twelve inches long, and of such diameter as to be nearly filled by 1000 grains of distilled water. It is graduated in the following manner. A strip of paper is pasted on one side of the tube, from top to base. The instrument is then counterpoised in a good balance, and 100, 200, 300, 400, &c., grains of distilled water weighed successively in it, adding one hundred grains on each addition, and making a pencil mark on the paper opposite the average level of the surface after each, till the tenth, when the tube will contain 1000 grains. The space between each division is then divided by a pair of compasses, into ten equal parts. The lines thus marked on the paper may be transferred to the glass by a file, and the graduation finished by the directions given in Chapter XV.

Fig. 364.



The scale is now numbered, every tenth degree being marked, commencing at the top, and progressing to the bottom,

which is 100. It is obvious that when this measure is filled with the test acid above described, each degree corresponds to one grain of anhydrous sulphuric acid. It is used in the following manner. Fifty grains of commercial soda ash, for instance, is treated with warm water till all its soluble matter is taken up; it is then filtered, and the washings mixed with the first solution, and placed in a capsule on a sand-bath. The measure is now filled with the test acid, which is then poured carefully into the alkaline solution, stirring constantly, until it is nearly saturated, as indicated by reddened litmus paper. The neutrality of the solution is then effected, by adding the test acid drop by drop. When this is ascertained, the number of grains of acid consumed is read off, and then the per-centage of real alkali found by proportion. Thus: suppose that thirty-five degrees of the acid have been consumed, then as the equivalent of sulphuric acid is to the equivalent of anhydrous soda, so is thirty-five to the quantity of soda in fifty grains of the soda ash: thus, as $40.09 : 31.27 :: 35 = 27.3$. By doubling the product the per-centage of real soda is obtained,—54.6 grains.

Potassa, soda, ammonia, or their carbonates, may be examined by this process with equal facility.

The process of *acidimetry* is similar in its character, a standard test solution of anhydrous carbonate of soda being employed. Two hundred grains of this salt is dissolved in sufficient distilled water to fill the alkalimeter measure, every degree of which will indicate two grains of the carbonate. One hundred grains of the acid to be examined is then carefully weighed, and diluted, and the solution of carbonate of soda gradually added until the solution is neutral, using blue litmus paper as the test.

Suppose one hundred grains of a specimen of nitric acid required 59.2 grains of carbonate of soda, as indicated by 29.6 degrees of the measure. Then as the equivalent of carbonate of soda is to the equivalent of nitric acid, so is the quantity of soda in the solution consumed to the amount of real anhydrous nitric acid in one hundred grains of the specimen, thus: $53.27 : 54 :: 59.2 = 60$. It follows from this that the acid tested contained sixty per cent of real acid, and by reference to the tables, its specific gravity is found to be 1.42.

A more simple but less accurate way is to weigh a quantity of well-crystallized bicarbonate of potassa, more than sufficient to saturate one hundred grains of the acid. This is reduced to powder, added carefully to the diluted acid until it is neutralized, and the residue weighed to ascertain the amount consumed. Then, as the equivalent

of the bicarbonate is to the equivalent of the acid on trial, so is the quantity of bicarbonate consumed to the per-centage of real acid in the specimen.

The strength of acetic acid is thus ascertained with sufficient accuracy for practical purposes, and as its specific gravity is not a correct index of its strength, even when pure, the pharmacist has to resort to this means frequently, to assure himself of the value of the commercial acid.

Sometimes fragments of pure white marble afford a convenient means of testing the strength of acids. A portion of these is weighed, and placed in one hundred grains of the acid, diluted in a capsule on the sand-bath, and heated gently until neutral. The fragments remaining are then washed in distilled water, dried, and weighed, and the loss noted. The result is then ascertained by proportion. As the equivalent of carbonate of lime is to the equivalent of the acid tested, so is the quantity of the carbonate dissolved to the per-centage of real acid in the specimen.

CHAPTER XIII.

GENERATION AND ABSORPTION OF GASES. REDUCTION BY HYDROGEN. WOULF'S APPARATUS.

THE processes for generating and absorbing gases are of frequent occurrence in the pharmaceutical laboratory. Among the gases thus operated upon, the most important are, carbonic acid, sulphuretted hydrogen, chlorine, ammonia, and muriatic acid. Of these, the three first-named, are more difficultly, and the two last-named, more easily, absorbed. The first two are evolved without the application of heat, but those which follow, require some heat to insure their complete evolution.

It will be necessary to describe the practical details connected with the generation and absorption of these gases separately.

Carbonic acid gas is produced by the action of sulphuric or muriatic acid on chalk, marble, or limestone.

When *sulphuric acid* is used, the insoluble sulphate of lime which is formed, tends to retard the reaction of the ingredients, by enveloping the undecomposed carbonate and protecting it from free contact with the acid. In operations on the large scale, it is customary to guard against this inconvenience, by having a stirrer attached to the generating vessel, by which the mixture is, from time to time, agitated, so as to remove the enveloping sulphate and bring fresh portions of chalk and acid into contact. *Muriatic acid*, on the other hand, forms a soluble salt with lime, which offers no material obstruction to the continuance of the decomposition: this acid is, therefore, better suited than the other for generating the gas for pharmaceutical purposes, as, in such cases, glass apparatus is generally employed, which is unprovided with means for stirring the ingredients.

The gas thus evolved, whichever process be adopted, is usually contaminated to a greater or less extent with the mineral acid, or with some volatile substance resulting from bituminous matter contained in the carbonate of lime. Before using it, it should be freed from these impurities, and this is especially necessary when muriatic acid has been employed, as an appreciable quantity of this volatile acid is

generally carried over with the gas. The best method of effecting its purification, is to make it pass through a semi-fluid mixture of bicarbonate of soda and water, or through a tube filled with fragments of the dry salt.

Fig. 365 represents the arrangement of the apparatus for generating, purifying, and absorbing carbonic acid. The vessel (*a*) contains the chalk, broken into pieces of a suitable size for being introduced through the mouth of the bottle. Crude muriatic acid, diluted with an equal volume of water, is poured in through the funnel-tube (*b*). The small bottle (*c*) contains bicarbonate of soda mixed with a little water; and the bottle (*d*), or some other suitable vessel, is intended to contain the liquid into which the gas is to be passed.

Fig. 366 represents another modification of the apparatus, in which

Fig. 365.

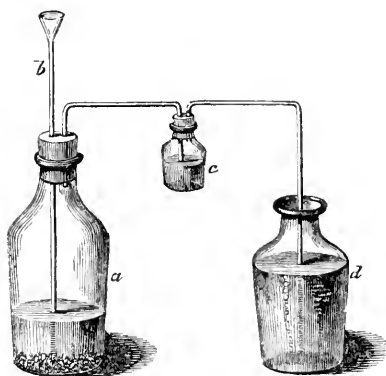
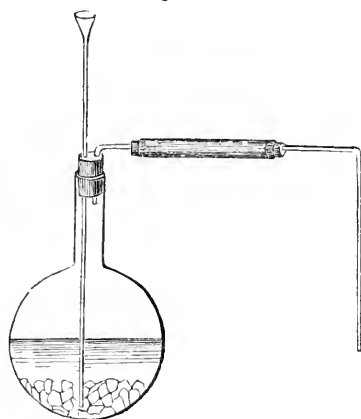


Fig. 366.



CARBONIC ACID APPARATUS.

a flask is substituted for a bottle as the generating vessel, and a tube filled with dry bicarbonate of soda is used for purifying the gas.

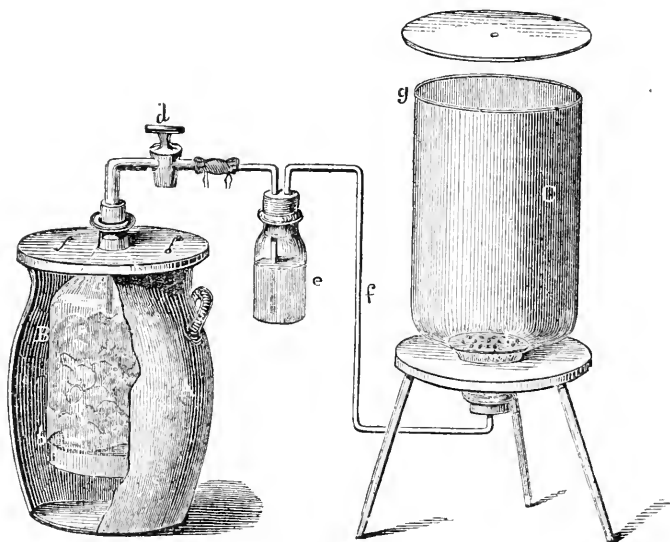
Towards the close of the operation, the further disengagement of gas may be aided by the application of heat, which is best effected by putting the generating vessel into warm water.

When the solution of chloride of calcium becomes somewhat concentrated, this prevents the further action of the acid on the carbonate, so that after the disengagement of gas has ceased, there may still be free acid and undecomposed carbonate of lime present. In this case, the addition of some warm water, poured in through the funnel-tube, will occasion a renewal of the reaction, which may be thus maintained until complete decomposition has been effected.

When broken pieces of marble can be obtained, these will be found greatly preferable to chalk as a source of carbonic acid gas. Not only will the gas be more pure and free from smell, but its disengagement will not be attended by so much frothing as occurs when chalk is used, and which, in the latter case, sometimes causes the contents of the generating vessel to pass over into other parts of the apparatus.

The arrangement represented in fig. 365 is that frequently adopted for effecting the absorption as well as the generation of carbonic acid; but when the gas is merely made to pass in bubbles through the liquid, as there indicated, the absorption often takes place but slowly and imperfectly, and it generally happens that the quantity of gas absorbed is not more than one-fourth or one-fifth of that which has been used. This loss of gas is sometimes of little importance, but there are cases in which it becomes a consideration to economize the expenditure of materials to the greatest extent practicable. With the view of accomplishing this object I have constructed an apparatus, in the use of which the disengagement of gas is dependent upon, and proportionate to, the extent of absorption which, at the same time, takes place.

Fig. 367.



CARBONIC ACID APPARATUS.

This apparatus is represented in fig. 367. It consists of the following parts:—first, a glazed earthenware jar (A), such as is commonly used for domestic purposes. The top of this is closed with a wooden

cover, in the centre of which there is a round hole through which passes the neck of the bottle (B), which is used for generating the gas. The wooden cover is in two pieces, being cut through its diameter, and these, when placed around the neck of the bottle, are kept together by two pair of hooks and eyes. The generating vessel (B) is a large green glass bottle, the bottom of which has been cut off. A brass tube and stop-cock (*d*) are fitted to the mouth of this bottle by means of a cork, and at the end of the tube which is inserted through the cork there is a hook, from which a circular plate of brass or lead is suspended by a wire for supporting the fragments of marble or chalk. This part of the apparatus resembles the gas-generator of the well-known Döbereiners lamp, which was originally invented by Gay-Lussac.

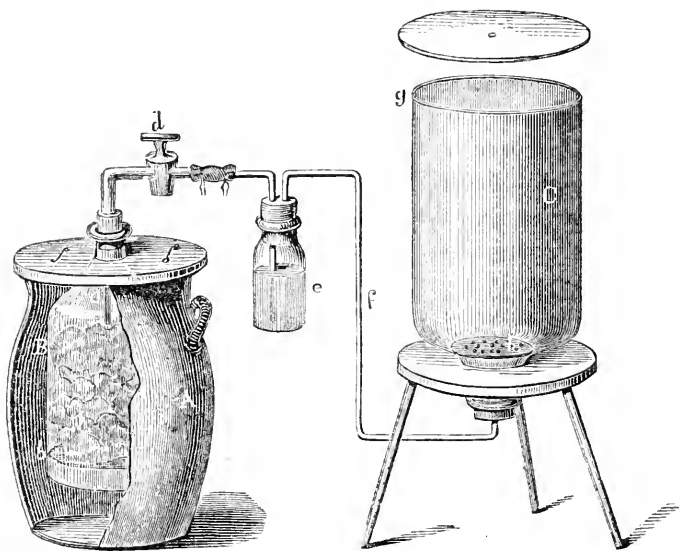
The generator (B) fig. 368 is filled in the following manner:—the circular plate being removed, the bottle is turned with its bottom upwards, and held by the wire attached to the end of the brass tube, while the pieces of chalk or marble are packed in so as nearly to fill it. The plate of brass or lead is then placed over the carbonate of lime, and the wire is passed through a hole in the centre of the plate, and secured by means of a nut, which screws on to the end of the wire. Crude muriatic acid, diluted with a little water, having been poured into the jar (A), the bottle (B) is fixed in its place, as shown in the drawing. So long as the stop-cock (*d*) remains closed, the acid will be prevented from entering the bottle (B) by the elasticity of the air contained in it, but on turning (*d*) the air will escape through the tube, and the acid coming in contact with the carbonate of lime, carbonic acid will be disengaged. If now the stop-cock be again closed, or there be any obstruction to the escape of the gas, the carbonic acid accumulating in the generator will displace the muriatic acid from the bottle B, and the further evolution of gas will cease. In proportion as the gas escapes from B, in consequence of its finding an exit at the other end of the apparatus, or being absorbed there, the muriatic acid will re-enter and decompose a further portion of carbonate, thus keeping up a uniform supply of carbonic acid equivalent to the consumption of it.

The other parts of the apparatus, as represented in the drawing, are intended for the preparation of *bicarbonate of soda*. The gas, after passing through the stop-cock (*d*), is purified in the manner already described, in the bottle (*e*), and is then conveyed through the tube (*f*) into the vessel (C). This vessel consists of a large bottle, the bottom of which has been cut off, and the edge (*g*) ground to a

perfectly smooth, flat surface, over which a circular disk of ground plate-glass, having a small hole in the centre, fits closely. There is also at the bottom of this vessel a perforated wooden disk (*h*), upon which the salt intended to absorb the gas is placed.

As bicarbonate of soda contains but one atom of water, while the carbonate contains ten atoms, it is found advantageous to use a mixture of three parts by weight of anhydrous, and one part of crystallized carbonate of soda. This mixture is put loosely into the vessel (*C*), so as nearly to fill it. The rim of the vessel is then covered with tallow, or other hard grease, and the glass-plate fitted on so as to be air-tight. The stop-cock (*d*) is now opened, and carbonic acid, being rapidly disengaged, soon displaces the atmospheric air from the apparatus, this gas escaping through the small hole in the glass plate which is not yet

Fig. 368.



CARBONIC ACID APPARATUS.

closed. When the air has been thus chased out, and it is found that carbonic acid begins to escape, the hole is to be closed with some wax, and the glass-plate loaded with weights to prevent any further escape of gas. Absorption of carbonic acid by the carbonate of soda will now commence. At first this will take place slowly, but after a little while the salt will become warm, and the action much more energetic. Indeed, the absorption, sometimes, proceeds so rapidly, that the solu-

tion is drawn over from the generator into the absorbing vessel. It is principally with the view of preventing this result that the stop-cock (*d*) is attached to the apparatus, as by this means the communication between the vessels (B) and (C) can be instantly cut off when the liquid is seen to rise unduly in the former. Hence it is necessary carefully to watch the process, at least until the action has ceased to be energetic.

[This apparatus of Dr. Mohr, which is on the principle of that of Dr. Hare, for hydrogen and sulphuretted hydrogen, does well enough where muriatic acid is used, and where the gas is not required under much pressure. But in the preparation of carbonic acid water, with excess of gas, to be used from the fountain, either a forcing-pump is required to condense the gas after its generation and collection, or the generation and condensation is effected at one operation in the *generator* used by the mineral water manufacturers. This consists of a strong egg-shaped copper vessel, with an agitator, the axle of which passes through air-tight joints at the sides, and is turned by a crank. Above this is a smaller copper vessel, communicating with the former, having a screw valve to close the connexion when desired. A third vessel for washing the gas, is also attached to the superior part of the generator. Into the latter a certain charge of powdered chalk, or marble-dust, mixed with water, is placed; into the second vessel, a proportion of sulphuric acid, sufficient to decompose the carbonate of lime, is poured, and closed. A tube passes from the upper part of the generator, through the top, nearly to the bottom of the washing vessel, which contains water, and which is connected with the fountain to be charged. As soon as the valve at the base of the acid vessel is opened, the acid descends and liberates the carbonic acid, which accumulates under great pressure until it has been drawn off. This apparatus may be employed in making bicarbonate of potash or soda.—W. P.]

Sulphuretted hydrogen is produced by the action of diluted sulphuric or muriatic acid on sulphuret of iron. As sulphuric acid forms a soluble salt with oxide of iron, and is less volatile than muriatic acid, it is used in preference to the other in this process. The gas may be generated in an apparatus similar to that represented in fig. 365. If a long-continued and slow evolution be desired, large pieces of the sulphuret, and very dilute acid should be employed; or if, on the other hand, it be wished to have a more rapid evolution, the sulphuret should be broken into small pieces, and a stronger acid used.

In saturating water with this gas it is desirable to have a brisk evolution of the gas. Distilled water should be employed, and this

should be kept at a low temperature. The following is the best method of conducting the process. Into two stoppered bottles introduce the cold distilled water, so that they shall be one-third full. Pass the gas into one of these bottles until it is completely filled with it, the atmospheric air being displaced; then transfer the gas-delivering tube to the second bottle, and immediately close the mouth of the first and shake it for some time, so as to bring the gas completely into contact with the water and promote its absorption. Meanwhile the second bottle will be filled with the gas, and the tube conveying it being again transferred to the other, this bottle with its contents is agitated until absorption is completed. In this way the process is repeated first with one bottle and then with the other, until it is found that no more gas is absorbed by the water. The saturated water is then put into small bottles, which should be completely filled, well stopped, and kept, with the mouths inverted, in a vessel containing cold water.

Sulphuret of ammonium may be prepared and preserved in the same manner.

When sulphuretted hydrogen is used for precipitating a metal from a considerable quantity of liquid, the latter should be put into a large vessel, a carboy for instance, the capacity of which is three or four times greater than the volume of the liquid, and the gas having been rapidly passed into the vessel until atmospheric air is entirely displaced, the vessel is to be shaken so as to promote absorption. A further quantity of gas is then, again, to be introduced, and the agitation repeated, continuing this process until no further precipitation takes place.

By operating in this way the decomposition is effected at a much smaller cost of time and materials than occurs when the gas is merely made to pass in bubbles through the liquid, for in this latter case much of the gas escapes without effect, while the liquid, in parts through which the bubbles do not pass, remains unacted upon unless it be brought into contact with the gas by agitation.

These remarks apply also to the process for preparing *hydriodic acid* by the action of sulphuretted hydrogen on iodine, and to that for the preparation of *hydrocyanic acid* from bichyanide of mercury according to Vauquelin's process.

[The arrangement of Dr. Hare for sulphuretted hydrogen is constructed of glass, analogously to that to be described for the generation of hydrogen (fig. 371). The sulphuret of iron should be in dense masses and placed several inches above the bottom of the inner vessel, so that, when the cock is closed, the acid liquid can recede below the

sulphuret, and the action cease without any of the gas escaping below the edge. It is always ready for use.—W. P.]

When sulphuretted hydrogen is used as a test, a very small phial may be employed for generating the gas. A few fragments of sulphuret of iron being put into the phial, together with some diluted sulphuric acid, and a bent tube inserted through the cork, this little apparatus may be applied to the glass or tube containing the liquid to be tested, as shown in figs. 369 and 370.

Fig. 369.

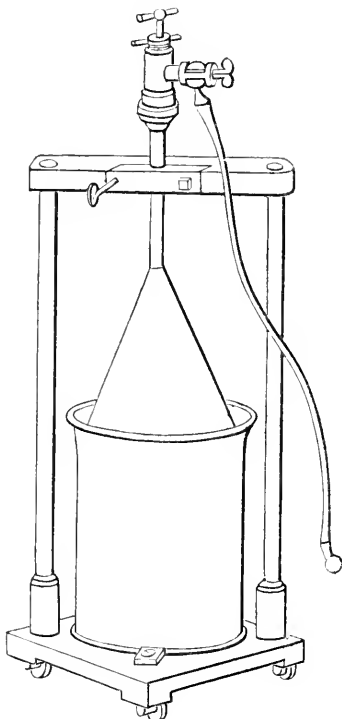


Fig. 370.



[*On the Generation of Hydrogen, and on the Reduction of Metallic Oxides by aid of that Gas.*—The best materials for generating hydrogen are zinc and sulphuric acid diluted with four times its bulk of water. The reaction takes place without the assistance of heat, and when only small quantities of gas are wanted, may be conducted in a wide-mouthed bottle (*a*, fig. 372,) with a funnel-tube, *b*, passing through the cork, and another tube, *c*, for conducting the gas to the apparatus wherein it is to be used. As commercial zinc often contains sulphur, in the form probably of sulphuret of zinc, there is frequently a little sulphuretted hydrogen generated with the hydrogen, and which it is necessary to remove before applying the latter for the purposes of reduction. This is effected by passing the gas through solutions of acetate of lead and lime, as represented at *i c*, fig. 373. When the gas is used in analysis, to ascertain the quantity of oxygen combined with a metal, it is dried by passing it through chloride of calcium, as at *e*, fig. 372.

Fig. 371.



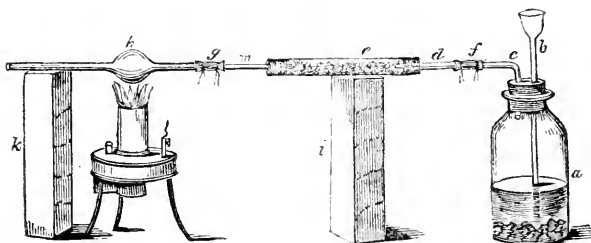
DR. HARE'S HYDROGEN GENERATOR.

The most convenient apparatus for generating hydrogen in quantity is the self-regulating reservoir of Dr. Hare, fig. 371, as it enables the

operator to control the current better than any other with which I am acquainted. This consists of a cylindrical leaden vessel, open at top and slightly flared at its rim. In this, another leaden vessel is placed, consisting of a cylinder, open at bottom, surmounted by a funnel-shaped top, to which is soldered a brass tube, mounted with a stop-cock, and furnished with a side gallows-screw for attaching a leaden tube. This is the reservoir for containing the liberated hydrogen previously to its escape through the tube. The zinc is suspended in a basket of copper wire, or it may be placed on a leaden stand resting on the bottom of the outer vessel just within the inner cylinder. The gas-holder is kept in position by a cross-beam of wood supported on two upright stanchions on either side, which are affixed to a block of wood upon which the generator stands.

The outer vessel of fig. 371 is about ten gallons capacity, the gas-holder about one inch less in diameter; about ten pounds of zinc is required for a charge. More could readily be introduced, but the presence of the large quantity of sulphate of zinc formed by its solution retards the reaction so much, that in practice, where there is an extensive demand for hydrogen, it is better to have two generators, and use them alternately. I have found it very convenient to have an S tube of lead surmounted by a funnel entering the gas-holder through the conical top, so that the additions of acid may be made through it directly on to the zinc, and as the diluted acid is lighter than the saline solution, it displaces the latter and remains on the surface in contact with the zinc.

Fig. 372.

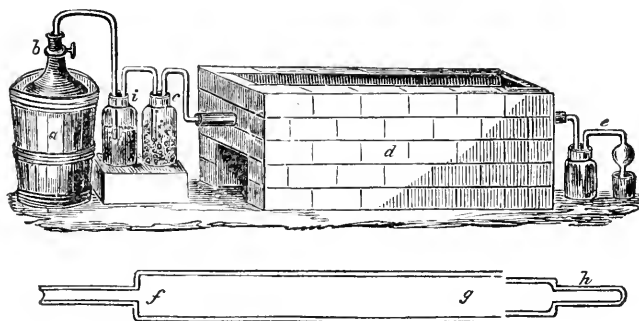


Reduction by Hydrogen.—Many of the metallic oxides are deprived of oxygen when they are heated to redness in an atmosphere of hydrogen, which is constantly renewed by a brisk current from a gas-generator. The arrangement of apparatus suitable for determining the amount of oxygen in a metallic oxide in analytical researches is repre-

sented in fig. 372. The bottle, *a b c*, is the gas-generator, *e d* the drying-tube, containing first small fragments of marble, and then chloride of calcium; *h* is a bulb-tube containing the oxide to be reduced, and which is kept hot by the lamp below; *f* and *g* are caoutchouc connectors; and *i k* are supports. The quantity of oxide introduced at *h* being known, and the current established until all the atmospheric air has been displaced, the heat is applied to the bulb until aqueous vapour ceases to pass out at the open end of the tube, when the bulb-tube is weighed, and the loss, which represents the quantity of oxygen, ascertained.

Reduction of Oxide of Iron by Hydrogen.—Within a few years, metallic iron, as reduced by hydrogen, has been employed in Europe as a medicine, and has been introduced into American practice by Professor Meigs. Fig. 373 represents the apparatus which I have used in preparing it for pharmaceutical purposes.

Fig. 373.



APPARATUS FOR THE REDUCTION OF IRON BY HYDROGEN.

The steps of the process are 1st, the preparation and introduction of the oxide into a suitable iron tube, *f g*, fig. 373; 2d, closing and luting the open end with the stopper, *h*; 3d, placing the tube in a temporary furnace, *d*, and arranging the materials for the fire; 4th, the generation and purification of the gas; and lastly the regulation of the fire, which is perhaps the most difficult part of the operation.

The form of oxide used is the subcarbonate of iron, of the U. S. Pharmacopœia, which has subsequently been calcined in an open vessel, with stirring, to remove the water of hydration. If this is not done beforehand, the texture of the product is materially influenced, being denser and more conglomerated. The best manner of introducing the oxide into the tube is to have a cradle of sheet iron of rather less diameter and length than the tube, and open along its upper side.

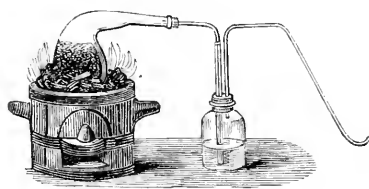
Into this the oxide is put, in mass, to the extent of four-fifths of its capacity, and the cradle slipped into the tube, the stopper luted in, and the tube then placed in position in the furnace. The lute best adapted is a mixture of fuller's earth, gum arabic, and a little syrup. The latter leaves a carbonaceous residue, which gives firmness to the clay and renders it less likely to crack.

Where hydrogen is a waste product, as in copperas manufactories, where that salt is made from scraps of iron and sulphuric acid, the gas may be advantageously appropriated to this purpose. From whatever source obtained, it should be first passed through a solution of acetate or subacetate of lead, and afterwards through lime-water, in order to free it from all traces of sulphuretted hydrogen. It is not necessary to dry the gas. The current having been started, and the air displaced from the whole apparatus, the fire is lighted. The fuel may be charcoal, coke, or anthracite. The best mode of proceeding is to make a charcoal fire, and gradually add stone coal until the tube is surrounded with red-hot coals. As soon as the tube has acquired a dull red heat, the draught is almost completely closed, and the operator should endeavour to keep it as near that heat as possible. On this depends the sponginess and levity of the product, qualities which not only add to its good appearance but render it more soluble. If the oxide of iron is not free from sulphate of soda, sulphuret of sodium will be formed, and render the iron valueless.

The hydrogen may be generated in large bottles, arranged as fig. 365, but is not so easily managed as in the generator of Dr. Hare.—W. P.]

Chlorine gas, when prepared in small quantities, is usually obtained from a mixture of peroxide of manganese and muriatic acid. When prepared on the large scale, the mixture of peroxide of manganese, common salt, and oil of vitriol, is more frequently employed. The

Fig. 374.



APPARATUS FOR GENERATING CHLORINE.

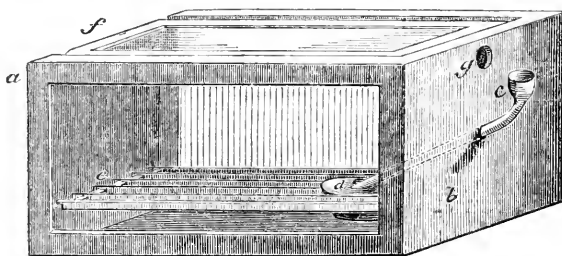
ingredients are put either into a flask, or a retort, fig. 374, to which heat can be applied by a lamp or charcoal fire. The gas ought to be purified, before using it, by passing it through water in a small wash-bottle, such as that shown in fig. 374.

The corks by which the tubes are fitted to the apparatus are generally much acted upon in this pro-

cess, and there is, therefore, an advantage in making the connexions by means of caoutchouc, whenever this is practicable.

In making a saturated solution of chlorine in water, the best method of operating is that recommended in treating of sulphuretted hydrogen. Two bottles, each one-third filled with water and the remaining space occupied with the gas, well shaken to promote absorption, and fresh gas added four or five times to supply the place of that which is absorbed, while the agitation is each time renewed, will afford a perfectly saturated solution of a greenish-yellow colour. In no other way, even with the best Woulf's apparatus, can so strong a solution be obtained, although by the latter process more time and material are expended. Whoever has once prepared chlorine-water in this way with two bottles, in less than a quarter of an hour, can but smile at the instructions given in some chemical works for using the complicated and expensive apparatus of Woulf, with its four bottles, twelve necks, and as many pierced corks and connecting and safety-tubes. This philosophical toy is already going out of use. For gases which are easily absorbed, such as ammonia and muriatic acid, it is not required, and for gases which are not so readily absorbed, such as chlorine, sulphuretted hydrogen, and carbonic acid, it is inefficient, or, at least, is less efficient than the method above described. The last-named gases pass rapidly through the water in bubbles, the volumes of which are but little diminished in their passage, especially if the gases be mixed with any quantity of atmospheric air. It is only by extending and renewing the contact of the gas with the liquid, by shaking them well together, that complete absorption can be effected. A temperature of from 48° to 50° Fahr. is that at which water is capable of dissolving the largest quantity of chlorine.

Fig. 375.

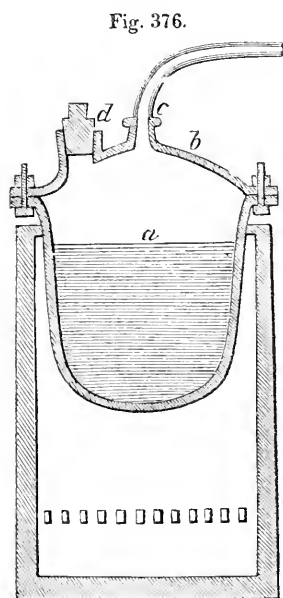


APPARATUS FOR BLEACHING SPONGE.

[Chlorine is employed by the pharmaceutist in the process for *bleaching sponge*, although from the injurious action of the muriatic acid

formed, on the fibre of the sponge, this mode of decolorizing it is less in vogue than formerly. The apparatus fig. 375, is intended as a reservoir for the chlorine during its bleaching action on the sponge. The latter is deprived of the sand which usually accompanies it, well washed and squeezed, to remove as much as possible of the moisture, and then placed on the lattice shelf (*e*) in the box. The latter is a tight wooden box (*a b*) with a sliding top (*f*), which, together with the two largest sides, are furnished with lights of glass, so that the operator can witness the progress of the bleaching process. The chlorine is generated in a flask or a retort, as in fig. 374, and conducted into the box by the opening, *g*, or it may be more readily but not so properly obtained by placing a dish, *d*, in the box, half filled with a paste of chloride of lime and water; the tube, *c*, penetrates the box, and opens over the centre of the dish. A mixture of equal parts of sulphuric acid and water is poured in through the tube to liberate the chlorine from time to time, until the bleaching action is concluded. The carbonic acid eliminated with the chlorine does not interfere in the result. The sponge, when sufficiently bleached, should be well washed, to remove all traces of acid, and dried in the shade.

The generation of *ammoniacal gas* for pharmaceutical purposes,



APPARATUS FOR GENERATING AMMONIA.

cannot eligibly be conducted in glass vessels. The most convenient form of apparatus for the purpose is that at fig. 376. This consists of a cast-iron vessel, *a*, with a flat flange; a dome-like cover, *b*, with a flange of the same kind, and which fits *a* accurately. There are two openings in the cover, one, *c*, for the exit of the gas; the other, *d*, larger, and for the introduction of the materials, and which is capable of being accurately stopped. The flange joint is put together with a thin layer of lute, consisting of clay and gum-water, and then the flanges approximated as closely as possible by means of the screw-bolts, of which there are four. This joint is taken apart after the exhaustion of the muriate of ammonia and lime, and the impure chloride of calcium removed readily with a chisel and spatula. The gas is conducted

from the opening, *c*, by a lead tube to the washing bottle, and afterwards by a glass tube, to the bottle or bottles for saturating the water or spirit, as the case may be. The following remarks relative to the safety-tube, and Woulf's apparatus, are pertinent to this process.—W. P.]

Notwithstanding what has been stated above with reference to Woulf's apparatus, it may sometimes be found convenient to use one or more of the bottles of which it is composed, in operating on gases. When a gas has to be passed through more than one vessel, there is an advantage in using bottles which have separate openings for each tube. The corks which are fitted into these openings are common bottle corks, of which there is no difficulty in finding those of suitable size, and each cork has but one perforation. After using the apparatus, if it be dismounted, the corks should always be taken out and kept in a drawer until wanted again, for if left inserted in the bottles, they lose much of their elasticity, and cease to form air-tight connexions.

Wide-mouthed bottles, the corks of which admit of two or three tubes being passed through them, are sometimes substituted for the Woulf's bottles; but not only are the corks used in this arrangement more expensive in the first instance, but if they be put away for subsequent use, they are not so easily refitted, on again mounting the apparatus, as would be the case with the smaller corks of the Woulf's arrangement. If the apparatus be not taken to pieces after using it, the corks should, at least, be taken out and left partially inserted, or merely resting on the mouths of the bottles, so that they may remain in a fit state for being tightly inserted when subsequently required for use.

Fig. 377 represents a convenient method of mounting a Woulf's bottle. Into the widest mouth of the bottle a glass tube, the diameter of which is as large as the opening for its insertion will admit, is cemented by means of sealing-wax, so that its lower extremity shall reach nearly to the bottom of the vessel. This tube is intended to form a permanent fixture in the bottle. The gas-delivering tube (*a*), the end (*b*) of which is slightly bent, passes freely through the wider tube, and when placed as shown in the drawing, the bubbles of gas as they issue at *b* rise into the upper part of the bottle without any portion escaping. The gas-delivering tube (*a*) may be larger in proportion to that through which it is inserted than the drawing represents, and it will then be unnecessary for it to be bent at the lower end, the

impetus with which the gas is conveyed being sufficient to cause the bubbles to pass beyond the mouth of the outer tube.

Fig. 377.

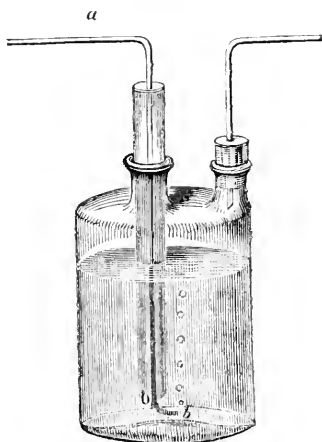


Fig. 378.



When a wide-mouthed bottle is used, the large tube may be fixed obliquely, as shown in fig. 378, in which case the gas, under any circumstances, would rise into the bottle without escaping through the space between the two tubes.

In using apparatus such as figs. 377 and 378 for the condensation of gases, it is always desirable to have a safety-tube attached to some part of the arrangement. If this provision be not made, there will be danger at the conclusion of the process, when the heat is withdrawn from the generating vessel, or from this or other cause the evolution of gas has ceased or partly subsided, while at the same time the absorption proceeds, or contraction of the volume of the gas takes place in consequence of reduction of temperature, that the pressure of the atmosphere, acting on the surface of the liquid in the absorption bottle, will force a portion of this liquid into the generating vessel.

The most simple arrangement of the *safety-tube* consists in the use of a straight tube passing through the cork and dipping into the liquid contained in the bottle. If there be but one absorption bottle, the safety-tube is attached to the generating vessel, as shown in fig. 379, and it can then be used for supplying fresh liquid to promote further evolution of gas. When the pressure of the gas within the apparatus

is greater than that of the atmospheric air, the liquid will be forced up this tube, and the length of the column thus sustained will indicate the amount of pressure within. On the other hand, should the pressure outside exceed that within, the liquid in the tube will be depressed below the level of that contained in the bottle, and on this depression reaching the bottom of the tube, atmospheric air will gain admission to the interior of the apparatus, and thus equalize the pressure.

Fig. 379.



Fig. 380.

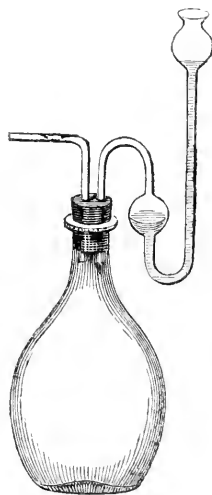


Fig. 380 represents a different arrangement, in which the tube is not made to dip into the liquid, but being bent in the manner represented, and furnished with a bulb in one of its short limbs, the liquid contained in this, when forced into the long limb, offers resistance to the escape of gas from within in proportion to the length of the sustained column, while, under different circumstances, air can gain admission from without, on its overcoming a pressure equal to the weight of a column the length of the short limb.

If there be any difficulty experienced in getting a bulb blown in the safety-tube, this may be obviated by substituting two tubes and a small bottle, arranged as shown in fig. 381, which will answer the same purpose as the safety-tube (fig. 380).

Sometimes, instead of fixing the safety-tube to the generating or absorption bottle, it is attached to the gas-delivering tube, as shown in fig. 382. This is called *Welter's safety-tube*. This arrangement is objectionable, inasmuch as there is some difficulty in uniting these tubes, and much danger of breaking them when used.

When two or more bottles, such as fig. 395 or fig. 396, are united to form a condensing apparatus, with a separate vessel for generating the gas, the arrangement constitutes a *Woulf's apparatus*. It is customary to use three-necked bottles in this arrangement, each bottle, as well as the generating vessel, being furnished with a safety-tube,

as shown in figs. 383 and 384. A is the flask in which the gas is

Fig. 381.

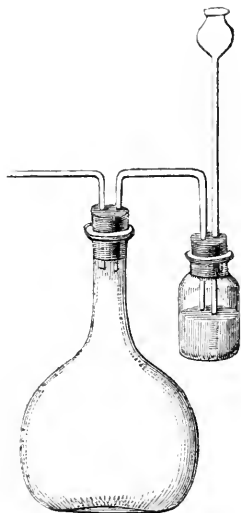
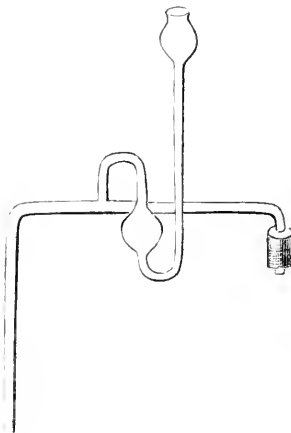
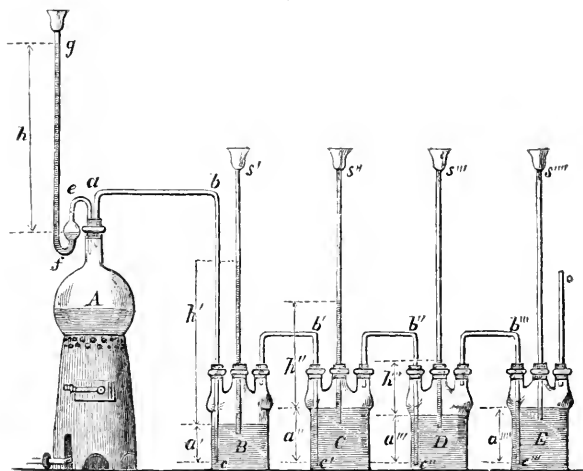


Fig. 382.



evolved, and B, C, D, E, the bottles for effecting the condensation of the gas.

Fig. 383.



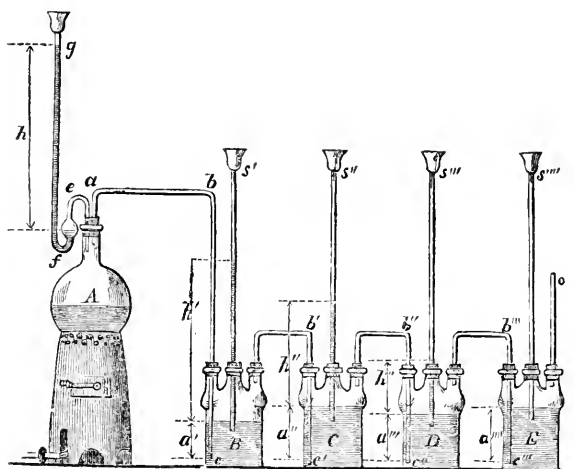
WOULF'S APPARATUS.

With the view of explaining the method of using the *Woulf's apparatus*, and the principle of its action, it will be well to describe what

occurs in applying it for a specific purpose. This may be the preparation of bleaching liquor by passing chlorine gas through solution of potash or soda. A quantity of peroxide of manganese is put into the flask (A), which is fixed over the lamp furnace, and the alkaline solution is introduced into the bottles (B, C, D, E). The connexions being made tight, muriatic acid is poured into the tube (*g*), until it reaches to the top of the short limb (*f e*). It will now be observed that the acid stands at the same height in this tube in the limbs (*f e*, and *f g*). It will also be observed that the liquid in the bottles (B, C, D, E), is at the same height within and without the tubes (*S'*, *S''*, *S'''*, *S''''*). These conditions indicate that the air within the apparatus and the atmosphere on the outside have the same degree of tension. On pouring more acid into the tube (*g*), it will flow over the bend at *e* into the flask, and, coming into contact with the oxide of manganese, chlorine gas will be evolved, which, adding its elastic force to that of the air previously present, causes an increase of tension here, and this acting simultaneously on the acid in the tube (*g*), and on the liquid in the lower end of the tube (*b*), the former is forced partly out of the short limb (*f e*), into the long limb (*f g*), and the latter is depressed until the gas, reaching the open end (*c*) of the tube, escapes into the bottle (B). The gas, as it passes through the liquid in B, will be partly dissolved, and the remainder accumulating in the upper part of the bottle, will add its elastic force to that of the air previously present there. This increased tension will be exerted upon the surface of the liquid in the bottle (B), and within the tube (*b'*) in the bottle (C), while the surface of the liquid within the tube (*S'*) will bear only the pressure of the external air to which it is exposed; a portion of the liquid from B will, therefore, be forced up into the tube (*S'*), and the weight of the column thus supported will be equivalent to the increased tension of the gas in the upper part of B beyond that of the external air. There will also be a like difference between the tension of the gas in contact with the surface of the liquid in the tube (*b'*), and that of the air in the upper part of the bottle (C), into which none of the gas has yet entered, so that the liquid in the lower part of *b'* will be depressed to a degree proportionate to this difference, and if the density of the liquids in B and C be equal, the depression of the liquid in *b'* will be to the same extent as the elevation of the liquid in *S'*. The gas, accumulating in B, will soon force the liquid out of *b'*, and escaping at *c'*, it will enter the bottle (C), where the same effect will be produced as in the previous bottle (B). From C the gas will pass into D; from thence into E, and any residue that may accumulate

here will escape through the open tube into the atmosphere. When the gas has commenced issuing from the tube (e''') into the bottle (E), it will be found that there will be a column of liquid supported in each

Fig. 384.



WOULF'S APPARATUS.

of the tubes (S' , S'' , and S'''), by the tension of the gas contained in the upper part of the bottles (B, C, and D). These columns of liquid will be of unequal lengths, the tension of the gas being different in each bottle. The liquid will not be elevated in the tube (S''''), because the gas in the bottle (E), having free means of escape into the atmosphere, will have the same tension only as the external air. The column of liquid h''' in the tube S''' will be equal to the column a''' ; the column h'' in the tube S'' , will be equal to $h''' + a'''$; the column h' in the tube S' , will be equal to $h'' + a''$; and the column h in the tube g , will be equal to $h' + a'$. Thus the columns of liquid in the safety-tubes indicate the degrees of tension of the gas in the bottles to which they are attached. The increased tension of the gas will tend to promote its solution, and this being greatest in the first bottle (B), the liquid in this bottle will become the most saturated.

The objects contemplated in the adoption of this form of apparatus are, the application of pressure to promote the absorption of the gas, and the extension of contact by making the gas pass through several successive quantities of the liquid.

If, in conducting the process under notice, the evolution of chlorine in the flask (A) should become suspended before the alkaline solution has been fully saturated, the absorption of the gas in the bottles still proceeding, or contraction of volume in the gas contained in the flask being caused by a reduction of temperature, the tension of the gaseous contents of the bottles and flask may become less than that of the external air. In this case the columns of liquid in the safety-tubes will entirely subside, and atmospheric air will enter the bottles through these tubes as soon as the tension of the external air exceeds that of the gas within to an extent equivalent to the weight of a column of the liquid the length of the immersed ends of the tubes. It is thus that these tubes act as safety-tubes, for without this provision the pressure of the external air on the surface of the liquid in the bottle (E) would force the liquid through the tubes b''' , b'' , b' , and finally through b , into the flask, thus causing a loss of part of the product of the process.

In conducting operations with gases of a noxious character, such as chlorine and sulphuretted hydrogen, it is desirable to avoid as much as possible the escape of the gas into the apartment in which the process is performed. This may be readily done with a Woulff's apparatus by lengthening the tube (o), and conveying the excess of gas beyond that which is dissolved or decomposed into a chimney or other means of escape.

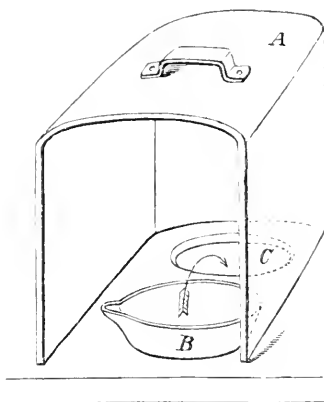
I have found the most effectual method of getting rid of chlorine and sulphuretted hydrogen, both of which are much heavier than atmospheric air, to consist in conveying them into the drain. This method is adopted in the laboratory of the Pharmaceutical Society, and it has been found most effectual. All analytical processes involving the use of sulphuretted hydrogen are conducted in an air-tight closet with glass doors, from which the surplus gas is conveyed through a pipe, four inches in diameter, into the drain.

There are some processes in which gases are evolved without any view to their subsequent condensation, and when these gases are of a noxious character it is important to prevent their contaminating the atmosphere of the laboratory. Gases of this description are disengaged during the solution of metals in nitric acid, and also in the action of oil of vitriol on some metals, such as copper and mercury. The application of heat is frequently required in these processes, and the means adopted for getting rid of the gases should, therefore, be reconcilable with this condition.

The furnace-hood, the use of which has been already alluded to,

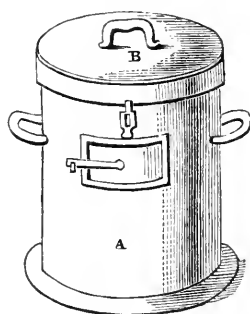
affords convenient and efficient means for accomplishing the object contemplated. Figs. 385 and 386 represent two different kinds of *furnace-hood*, which are used in the laboratory of the Pharmaceutical Society. Fig. 387 has been already described at page 128. Fig. 386 is a more complicated and expensive apparatus, but it is more efficient than the other, especially if there be not a good draught to the furnace. A, fig. 386, is a cylinder fourteen inches in diameter,

Fig. 385.



FURNACE-HOOD.

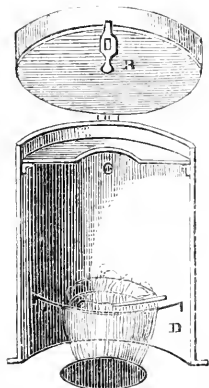
Fig. 386.



FURNACE-HOOD.

and eighteen inches high, made of galvanized iron, painted; it is open at the bottom, furnished with two handles attached to the sides, and one to the centre of the lid, and a door as shown in the drawing.

Fig. 387.



SECTION OF FURNACE-HOOD.

Fig. 387, shows a section of the apparatus, with the lid partly raised. Immediately under the lid there is a movable plate (C), which rests on a ledge, and has a circular hole, six inches in diameter, in the centre. About four inches from the bottom there is a ring six inches in diameter, attached by three supports to the sides of the cylinder, as seen at D. The section (fig. 387) represents the apparatus in use, placed over the open mouth of a ring-topped furnace. The lid being opened, and the plate (C) removed, a Wedgwood's dish, or other similar vessel, is introduced at the top, and placed on the ring (D); the plate (C) is now returned to its place, and

the ingredients to be operated upon put into the dish through the door, or through the opening at the top. The dish is, of course, exposed to the heat of the furnace, and any gas or vapour which may be disengaged is carried into the furnace by the pressure of the superincumbent cold air, as shown in the drawing.

CHAPTER XIV.

[GENERAL OBSERVATIONS ON THE PREPARATION AND PURIFICATION OF THE FIXED OILS AND FATS EMPLOYED IN PHARMACY, AND ON CERATES, OINTMENTS, SOAPS, AND PLASTERS.

A LARGE number of fatty bodies are employed in pharmacy, either as internal medicines, *per se*, or in the form of emulsions or mixtures, or for external application, as cerates, ointments, liniments, soaps, and plasters. They may be divided into two classes, fluid fats or *fixed oils*, and solid fats or *fats proper*. They are all composed of several proximate principles, as stearin, margarin, and olein, together with some, peculiar to particular oils. The first two are solid and crystallizable, the last, fluid; and the consistence of all natural fatty bodies is due to the relative proportion of their solid and fluid constituents. They all have a tendency to absorb oxygen, and undergo a change, which is called rancidity, and during which a portion of the neutral principles are converted into fatty acids and glycerin. The presence of water and of air, incorporated with solid fats, induces this change more rapidly, as also does the presence of nitrogenous animal matter. Hence it is a point of prime importance in the preservation of this class of substances, to protect them from the air.

Heat also acts injuriously upon them, not only by directly decomposing the neutral principles, but by rendering them more obnoxious to the ill effects of atmospheric air. Consequently, in manipulating with oils and fats, either for their extraction, or in the preparation of cerates and ointments, a view should be had to this ill influence.

Fixed oils are obtained by three processes: by expression, by boiling the oil-yielding substance with water, and by dissolving them out with a menstruum.

The manner of extracting oils by expression, has been generally explained in describing the process of expression, Chapter VIII.

In the arts, the wedge-press is esteemed the most practicable for this use, especially where the oils are quite fluid, like linseed oil; but for castor oil, the hydraulic-press, or a compound screw-press, is more generally preferred; a constant pressure being more appropriate than when suddenly increased by jerks.

The oil as it runs from the press is rarely fit for use. It has, in the case of castor oil, albuminous and watery particles admixed, and requires to be boiled with water, during which the albumen is coagulated, rises to the surface, and assists in the clarification of the oil. This is skimmed off, the oil laded from off the surface of the water after boiling, and is subsequently heated to remove the watery particles which adhere to it. It is in this last operation that the oil is most liable to be injured, because as soon as the water is vaporized, the temperature of the oil rapidly rises, and it acquires acrimony in proportion. If steam heat, under a pressure of one or two pounds per inch, were employed, no such injury would result.

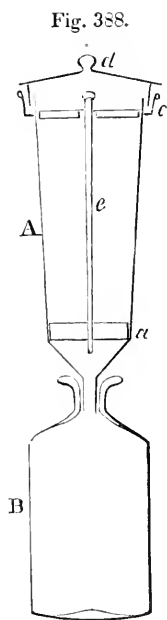
Fixed oils are generally coloured, though not so naturally. The yellow hue of the oil of almonds is due to the colouring matter of the episperm of the kernel, and to the yellow dust which adheres to it, due to attrition. The separation of these by blanching would be too tedious, although sometimes done for particular uses. The colour of commercial castor oil is due partly to the episperm, partly to the casks in which the oil is contained, but chiefly to the heating of the seed before, and of the oil after, expression. The linseed oil of commerce is often very much modified by the process of making it. The seeds are partly torrefied, not only to make the oil more fluid, but to render it clearer as it flows from the press. It would be much more agreeable for internal use if the same precautions were observed in its extraction that are recommended in the case of castor oil.

The second process, by boiling the bruised seeds in water after having gently torrefied them, and skimming off the oil as it rises to the surface, was formerly adopted in making castor oil; and much of that now used for domestic purposes in the West Indies, is thus made by the negroes. Oil thus prepared is greatly inferior to that extracted by expression. This second process is resorted to in the extraction of cod-liver oil. The livers freed from the membranes are cut in pieces, placed in a tin vessel with a portion of water, and heated. The oil gradually rises to the surface and is skimmed off, to be subsequently clarified by straining, &c. The more recent the livers, and brief and moderate the heating process, the lighter coloured and less offensive the oil.

The more common commercial variety is obtained by throwing the livers in heaps, exposed to the sun, during which they undergo decomposition, and the oil, dark-coloured and rancid, flows from them to a suitably arranged receptacle. According to M. Jongh, the light-coloured, carefully prepared oil, contains more iodine and bromine than the dark rancid variety.

The third process, by solution, is applied in but few cases. Castor oil is sometimes, owing to its solubility in strong alcohol, extracted by boiling the seeds in that liquid, and subsequently regaining the alcohol by distillation; but this plan has nothing to recommend it to the manufacturer. Croton oil is obtained by mixing the ground seeds with half their weight of alcohol, and after standing, submitting them to pressure, renewing the operation a second time, and subsequently distilling off the alcohol. This oil is thick and viscid, like castor oil, and does not flow from the press readily,—hence the introduction of the alcohol facilitates its extraction; and it is probable that in the case of castor oil, the use of alcohol in this way would equally facilitate its separation, whilst it would avoid the albuminous matter that usually flows out with it. As the beans would have to be ground, it is possible that the oil would be more coloured than when simply expressed in the usual manner.

Ether is used with great advantage in the isolation of fixed oils, when its cost is not an objection, and when other principles, soluble in it, are not associated with the oil to be extracted. Oil of ergot is obtained by this liquid. The ergot in powder is introduced into a displacer, such as fig. 388, shaken down till well packed, and then treated with ether until twice the weight of the powder is obtained. The ether is recovered by distillation with a water-bath at 120° Fahr.



DISPLACER FOR
VOLATILE LIQUIDS.

When the oils are solid at ordinary temperatures, as those of nutmegs, cacao, and laurel berries, the material containing them is ground, made into a paste with hot water, enclosed in sacks, and immediately expressed between hot tin plates. Mohr has described a plan of constructing the plates for this purpose at page 219. Such of these oils as contain volatile oils, as the first and last of those mentioned, are injured in value by too long an exposure to heat during their subsequent clarification.

In the filtration of fixed oils, with a view to their clarification, they are more or less injured by the thorough exposure to the air as they pass slowly through the filter. The conical cotton or woollen filter, figured at page 190, is the best form for large quantities of oil. When time permits, the best manner of purifying them, is to keep them in tall tight vessels, in

a warm place if in winter, until the feculent matter has deposited, so that the clear supernatant oil may be drawn off. Tin canisters, twelve inches in diameter, and two feet high, with two cocks, one about three inches from the bottom, and the other midway between top and bottom, afford the best arrangement for the retail pharmacist. The upper opening is intended to draw off the upper stratum as soon as the oil above it is clear.

When fixed oils are to be decolorized, they are passed through a stratum of granular animal charcoal, and to facilitate the filtration the temperature should be raised to about 120° or 150° Fahr. The apparatus, fig. 389, affords a ready means of accomplishing this, and has been described at page 211. It is very important that the charcoal be entirely free from dust, else the minute particles will pass with the oil and render it impure.

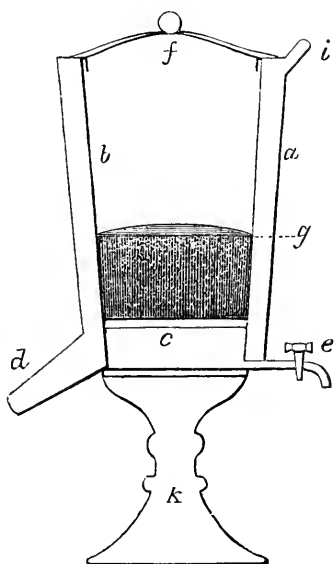
Fixed oils are also decolorized by exposure to the sun's rays enclosed in glass vessels.

In the manufacture of palm oil, for soap, it is bleached by the process of Watt, with chromic acid. A mixture of bichromate of potash and sulphuric acid is introduced into the coloured and impure oil mixed with water, and the whole boiled until the colour is discharged; the green oxide of chrome, sulphate of potash, &c., being subsequently separated by water and subsidence.

The fats of animal origin chiefly used in pharmacy are *lard*, *suet*, and *beef's marrow*.

Lard, the adipose matter of the hog, varies much in value, for pharmaceutical purposes, as found in commerce. This arises chiefly from the frequent want of care in its preparation, and partially to the part from which the lard is obtained. The fatty deposit of the omentum, mesentery, and in the region of the kidneys, is that most appropriate for pharmaceutic use, because it requires less heat in rendering it, and the lard has a smoother and more homogeneous texture. So important is good lard in the fabrication of some cerates and ointments, that when it is not attainable of unexceptionable

Fig. 389.



CHARCOAL FILTER FOR DECOLORIZING.

quality, it is worth while for the apothecary to render it himself from selected fat. This should be cut in small pieces, freed as much as possible from the adhering membranes, introduced into a boiler with a portion of water, and boiled until the fat is fused from the cellular tissue, in which it is naturally deposited, and the water has all evaporated. As soon as this is the case, and before the temperature of the fat rises much above 212° , it should be dipped out and strained. It is the excessive heat applied at this point of the process, together with its influence on the pieces of flesh and membranes which generally accompany the crude fat, that the inferior quality of much of the commercial lard is attributable. Lard should be entirely free from moisture, and when salted, as is sometimes the case, should not be used without previously washing it with warm water. Lard prepared as above, if run into glazed stone jars, and securely covered from the air, will keep perfectly good from season to season.

The process of rendering suet is the same as for lard; its higher fusing point, however, requires more time to effect it.

Beef's marrow is obtained in a crude state from the butcher; that from the large round bones is to be preferred. In this form it contains cellular tissue, blood-vessels, pieces of bone, &c., and after having been well washed in cold water, is boiled with that fluid until the fat is entirely extracted from the tissues, when it is suffered to cool and solidify. The impure marrow is now taken from the water, and heated until all the adhering moisture is evaporated, when it is strained; if to be used for application to the hair, it is then perfumed.

Butter is sometimes employed as a vehicle for oxide of mercury and other substances, as an application in ophthalmic diseases. When used, it should invariably be washed in warm water, to remove the salt always added to it.

CERATES AND OINTMENTS.

Cerates are medicines for external application, consisting of wax and a fatty substance as a basis, with which resins, mineral powders, and other substances are incorporated. Their consistence is such, that at the temperature of the skin they will soften, but not liquefy. The presence of wax, as their name infers, is an essential constituent of these preparations.

Simple cerate, which may be considered as the fatty basis of a number of medicated cerates, is a compound of two parts of lard and one part of white wax, and from its extensive use as a dressing to

irritated surfaces, it is one of the more important though one of the simplest preparations in the range of the shop. The injurious influence of excessive heat on fatty substances has been alluded to. In all those cerates valued for their mildness, attention should be given to this point in their preparation. The lard and wax after liquefaction should be strained into a large Wedgwood mortar and triturated until it chills, and has assumed a uniform texture, entirely free from waxy granulations, and very white. It is usual with some pharmacutists in Philadelphia, to add to simple cerate and ointment a small quantity of borax dissolved in rose-water, with a view to whiten them. This addition has been objected to by some physicians, but in the majority of instances no fault has been found with its use. The borax appears to act on the fat precisely as though it were free soda. About a scruple of borax dissolved in a fluid ounce of rose-water, is mixed with each pound of melted cerate, and it is best to warm the mortar with the solution in it before adding the cerate, so that the latter will not be chilled too rapidly.

It should be the aim of the pharmacist to be able to furnish simple cerate on every occasion, entirely free from the rancidity acquired by age and exposure. In order to do this, the quantity prepared should always be suited to the probable demand, so that it shall not be long on his hands. The most effectual plan is to introduce a quantity of cerate, capable of lasting a month, into well-glazed half pint or pint jars, each full and covered closely with a sheet of tin-foil, so as perfectly to exclude the air. These jars may be of such size as to fit within the regular shop jar. They should invariably be washed in hot alkaline water before being used a second time. If this method is followed, there will be no complaints from patients or physicians.

When a cerate is intended to irritate instead of soothe, the same regard to temperature is not necessary, and it is sometimes advisable to heat the medicating substance in the cerate, with a view to dissolving out some active constituent of it more effectually, as for instance, in the case of cantharides. When mineral powders are to be added to cerates, the same precautions in reference to their state of division should be observed as will be noticed under the head of ointments.

Cerates containing resin generally keep better than those made with wax and lard alone, of which fact, the common resin cerate is evidence. Cerate of subacetate of lead, is so strongly disposed to change and become rancid, that some prefer to prepare it extemporaneously by triturating simple cerate with the proper proportion of solution of subacetate of lead and camphor, the latter being added in the form of camphor liniment.

Ointments, like cerates, are medicines for external application, but their consistence is so much softer than that of cerates, that they can be applied to the skin by anointing, and hence their name.

Simple ointment consists of four parts of lard and one of white wax, combined in the same manner by fusion and trituration, as has been mentioned for cerate. Simple ointment is less frequently used than cerate, and requires similar precautions to keep it in good condition. It is the basis of a large number of medicated ointments.

Medicated ointments may be divided into three classes :

Those consisting of simple ointment or lard, and certain powders or liquids mechanically mixed.

Those which are prepared by dissolving the medicinal substance in the melted ointment or lard, and

Those which require chemical reaction between the fatty matter and the added substance.

The *first* kind, which includes the majority of the officinal and extemporaneous ointments, are mixtures of ointment, lard or laurel oil, with mineral salts, metallic oxides, organic principles, and other solid substances. The chief points requiring attention in making them are, that the medicating substances, if insoluble, be reduced to the finest possible state of division *before* being mixed with the vehicle, and then uniformly disseminated through it; or if soluble, that they be dissolved in, or triturated with, a small portion of water or alcohol, as the case may demand, until they dissolve, or assume a pasty consistence, and then admixed. The presence of hard gritty particles in ointments should never be tolerated by physicians, and always indicates carelessness or want of skill on the part of the dispenser.

In making iodine ointment, the iodine should be triturated with one-fifth of its weight of iodide of potassium, and a few drops of water, to form a dense solution, previously to adding the lard. When merely triturated with alcohol, unless the strictest care is exercised, particles of iodine will escape comminution, and give a speckled appearance to the ointment.

When extracts enter the composition of ointments, if not of soft and even consistence, they should be rendered so by triturating them with a little water, so that no separate particles will be visible in the finished preparation. The ointments made from the extract of stramonium and belladonna are instances.

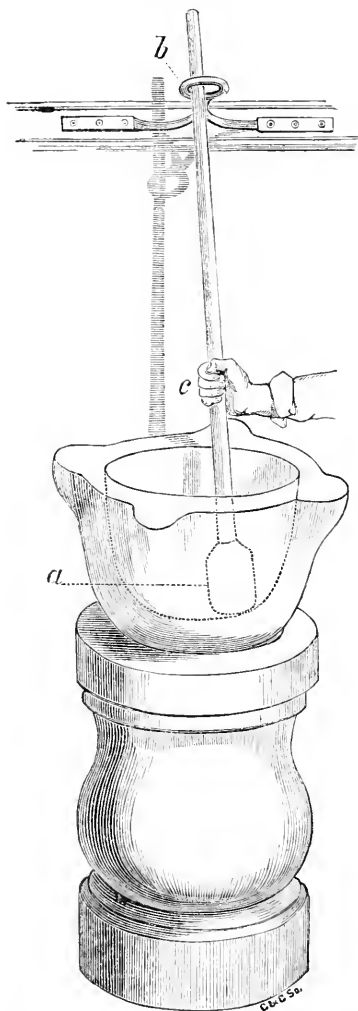
Mercurial ointment belongs to the first kind, and requires a special notice, as involving some particular manipulation. Perhaps no preparation, so simple in its constitution, has had more written about the mode of making it, or so many opinions of its nature expressed.

Writers have usually aimed at shortening the trituration necessary to *extinguish* the mercury, that is, to divide it so minutely through the fatty vehicle, that the globules are not visible with a lens of three powers; or at deciding on the exact condition of the mercury as it exists in the ointment, viz., whether it be wholly, partially, or not at all oxidized. When the fatty materials are fresh and pure, the process by continued rubbing is excessively tedious. The principle upon which the mercury is divided is simply to triturate it with a substance capable of adhering to the surface of the globules, and preventing them from coalescing after they are once separated, either by staining the surface of each globule by a coating, extremely minute, of oxide of mercury, or with some sticky resinous or fatty body. Balsam of sulphur, oil of egg, and sulphur itself have been recommended as agents in extinguishing mercury, and they act by causing the surfaces to be stained with sulphuret of mercury; but this is not a justifiable addition. This ointment can be made, however, without resort to any foreign substance, and in a reasonable time, by the following process, suggested by MM. Coldefy and Simonin. The mercury is triturated with lard prepared in the following manner. It is melted and poured in a thin stream into very cold water, so that it instantly solidifies on entering that fluid. By this means the lard is divided into strings, or ribands, with a very extensive surface. In this form it is placed in a cool cellar, so that it will not run together, and is exposed to the action of the air for a month or two until the lard becomes rancid and sticky. Three weeks' exposure will enable it to extinguish seven or eight times its weight of mercury, and after three months' exposure it is said to reduce thirty-two times its weight of mercury to the extinguished condition, with equal facility, by triturating them together. Old rancid simple cerate, to the extent of one-eighth of the mercury employed, will answer perhaps quite as well. Some employ one-eighth of old mercurial ointment, that has become rancid by age, which, also, is very effective. After the extinguishment of the mercury, the remainder of the lard in a pure state is incorporated with it, and when uniformly mixed, the process is complete. Mercurial ointment is usually prepared on a large scale, by steam-power.

Fats by becoming rancid acquire an adhesive quality not noticed in their fresh state, and this appears to be the cause of their power to extinguish mercury. It is possible that in this condition they contribute to the oxidation of the surfaces of the globules, a condition that is most effective in rendering the extinguishment perfect. As mercurial ointment acquires age, its colour deepens, a change most probably due to the further oxidation of the mercury. That mercurial

ointment contains protoxide of mercury, is placed beyond doubt by the experiments of Donovan, who, after separating the mercury from the ointment by keeping it melted, found that the transparent hot fat was instantly coloured black by a stream of sulphuretted hydrogen. He further has shown that an ounce of lard will dissolve twenty-one grains of protoxide of mercury, when digested at a temperature of 160° Fahr., for some time, and has recommended this mercurialized lard as a substitute for the officinal ointment, believing that it is only the oxide in the latter that gives it medicinal powers.

Fig. 390.



MARBLE MORTAR FOR MERCURIAL OINTMENT.

When mercurial ointment is prepared by hand, it is best made in a marble mortar with a long pestle, arranged as at fig. 390. The operator should endeavour to keep the sides as free from the globules as possible, by frequently removing the ointment which adheres to them with a spatula, so that the progress of the whole mass shall be uniform. With the lard prepared as stated above, or with old cerate or mercurial ointment, four pounds or more of this preparation may be made in a mortar in as many hours.

Some further observations relative to manipulating with ointments will be found in Chapter XVII., under the head of OINTMENTS.

The *second* kind of ointments are those in which the medicating substances are dissolved in the fatty matter whilst in a melted state, of which tobacco, stramonium, and carrot ointments are instances. When the substance to be treated consists of recent vegetable structure, it is bruised, placed in the lard or ointment previously melted, and heated until all the water of vegetation is evaporated. As soon as this is accomplished, which is known by the cessation of the boil-

ing, the heat should be reduced, the temperature not being allowed to much exceed 212° Fahr., until the colouring matter of the leaves, if these are treated, has been partly extracted, which is an index of the sufficient action of the solvent. The ointment is then strained. If wax is to be added, it should be fused with the lard before the straining.

As these ointments have to be made at those seasons of the year when the recent plants can be procured, they are necessarily made in quantity, and some means should be adopted to preserve them from rancidity. The most efficient method of preserving them, besides the usual one of enclosing them in jars, covered with tin-foil, is the suggestion of M. Dechamps. This pharmacist having noticed that resinous ointments were less disposed to be affected by the air than others, conceived the idea of associating some substance with them, which would act in a similar manner. He found that benzoin would fully accomplish the desired end, and under the name of benzoated lard has recommended a preparation for use in extemporaneous pharmacy for ointments. One part of powdered benzoin is heated by a water-bath with twenty-five parts of lard, for two or three hours, and then strained and triturated in a mortar as it cools. Poplar buds, when heated with fats, act even more efficiently. The lard acquires a slight odour of the benzoin, and very little colour. Nearly all ointments, except those for highly irritable surfaces, may be made from this prepared lard,—and in the case of the ointments of red oxide of mercury, white precipitate, and iodide of potassium, it prevents or greatly retards the chemical changes that usually occur in them by keeping.

The *third* kind of ointments are those in which chemical reaction takes place between the fatty matter and the added substance, in the process of making them, and are few in number. The ointment of nitrate of mercury is the most common of them. In making citrine ointment, as it is called, the reaction must be sufficient between the excess of nitric acid, in the acid nitrate of mercury, and the fat, to convert the olein of the latter into elaidin, else the consistence of the ointment will be hard and crumbly. If the nitric acid is of less strength than 1.45 sp. gr., the quantity used should be increased in proportion to its weakness. Perhaps the most important point in the process is the temperature of the fat at the moment of adding the acid mercurial solution. It should be 180° Fahr., and after stirring in the solution, an active reaction should be manifested by effervescence, and the liberation of nitric oxide. If the quantity of nitric

acid is too small, the oxidation is apt to be carried on at the expense of the nitric acid of the nitrate, and a portion of mercury deoxidized, which will subsequently discolour the ointment in spots. It is hardly necessary to observe that in manipulating with ointments of this kind, metallic spatulas should be avoided.

SOAPS AND PLASTERS.

When fixed oils and fats are boiled with a solution of fixed alkali, their proximate constituents are decomposed, alkaline salts of stearic, margaric and oleic acids are obtained, and glycerin is eliminated. The mixed fatty salts, deprived of the excess of alkali and the glycerin, and associated with a greater or less quantity of water, constitute the different soluble soaps of commerce. Medicinal soaps are of two kinds, those that are soluble in water and those that are insoluble. The first constitute the soaps proper, the second, plasters.

Soaps made from olive oil and soda, and from animal fat, or tallow, and soda, are those recognised by the U. S. Pharmacopœia. The soda salts of the fatty acids have a firmer consistence than those of potash, the latter yielding soft soaps. Animal fats yield firmer soaps than vegetable oils, because they contain much stearic acid, and such soaps containing stearate of soda are those proper for making opodeldoc.

The usual method of proceeding in saponifying oil, is to prepare a soda lye from barilla, or soda ash and lime, in the manner of making solution of potash, so that it shall contain about six per cent. of alkali. This lye is placed in a suitable boiler, (and for this purpose a coil of tube, heated by pressure steam, is the best mode of applying the heat,) with the oil or fat, and boiled until the lye has been exhausted. The spent lye is then drawn off, and more added and boiled, which is repeated until the saponification is completed, which is known by the consistence of the saponaceous fluid. Common salt is then added, which is dissolved by the water, forming a brine in which the soap is insoluble. The quantity of salt is so regulated that it will divide the water between the soap and itself. The soap is then laded out of the boiler into suitable moulds, and constitutes grain soap. When it is wished to make the soap very white, the grain soap is again boiled with a quantity of water, and separated a second time.

The "medicinal soap" of the French Codex, which is made by the pharmaceutists, and used for internal administration, is a soda soap

of oil of almonds, and known under the name of amygdaline soap. It differs from other soaps in containing all the glycerin, and a quantity of carbonate of soda. It is made by mixing ten parts of oil of almonds, with twenty-one parts of a concentrated solution of caustic soda, of sp. gr. 36° Baumé, in a porcelain vessel, and stirring the mixture occasionally for eight or ten days, at the expiration of which time the mixture will have solidified. The soap is then cut into thin slices or bars, piled up in such a manner that the largest extent of surface will be exposed, and left to the action of the air for two or three months, until the excess of caustic soda absorbs sufficient carbonic acid to convert it into carbonate, which, in a great measure, effloresces on the surface of the soap as it dries.

Medicinal soaps are sometimes formed with soap and medicinal resins, like those of jalap and guaiacum. One part of jalap resin, and two parts of soap, are dissolved in a sufficient quantity of alcohol, 32° B., and evaporated to the pilular consistence. The soap renders the resin more soluble in the liquids of the alimentary canal, and modifies its action.

Plasters are external applications, of a consistence thicker than cerates, and of such tenacity and adhesiveness at the temperature of the human body, that when applied to the skin they will adhere without slipping.

They are of two kinds; those which consist of *oleo-margarate of lead*, or lead plaster as a basis, united to resinous and other substances, and which are properly called plasters; and those which consist of resins alone, or these united with fatty substances or wax.

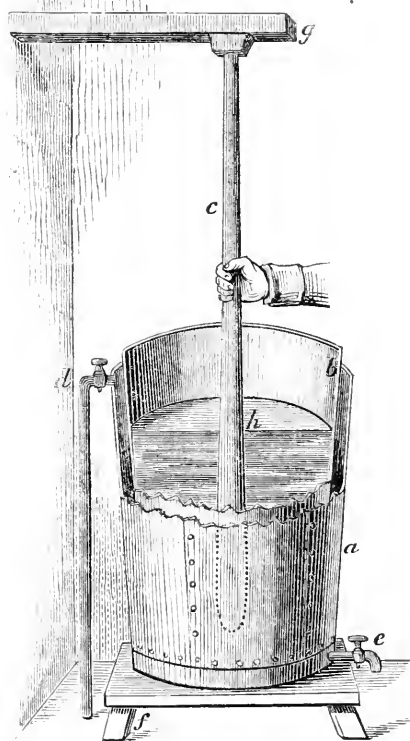
Lead plaster is an insoluble soap of lead; it is a compound of the oily acids of olive oil, with oxide of lead, and as usually found in the shops contains a portion of glycerin. Its preparation forms an extensive item in the business of the pharmaceutical laboratory. The conditions for the formation of lead plaster are, that olive or lard oil, or these mixed, be heated with litharge in fine powder in a certain proportion, and with the presence of water, which is essential to the chemical changes that occur. All kinds of fixed oil do not answer equally well for this use, and from the researches of M. Henry and others, lard or lard oil is the only good substitute for olive oil. In reference to the oxide of lead, the presence of the oxides of iron or copper in it, unfit it for making plaster, and attention should be given to this fact. In Europe, where impure litharge is more frequently met with than here, the manufacturers of plaster frequently assay its quality by making a small quantity of plaster as a test.

The apparatus for making plaster on a small scale, consists of a

hemispherical copper pan with handles, a wooden spatula, and a regular source of heat. The capacity of the pan should be one-third or one-half greater than will be occupied by the ingredients, so as to allow for the swelling of these during the boiling. The oil is introduced into the pan with one-tenth of its bulk of water, and the litharge introduced by means of a sieve, to break up the lumps. They are then boiled together, with constant stirring, adding small quantities of hot water from time to time until the combination is completed. This is known when a small portion of the plaster, cooled and cut through, exhibits no particles of litharge unacted on. Another index of the completion of the plaster is, that in stirring perfect plaster rapidly, little bubbles like soap bubbles are given off, owing to the escape of air, which is not the case as long as any of the oil remains unsaponified.

The best arrangement, with which I am acquainted, for the manu-

Fig. 391.



facture of plaster on a large scale, is that of Robert Shoemaker of this city, who has kindly permitted me to figure his apparatus, and to describe the process as conducted at his laboratory. Fig. 391 represents this apparatus. It consists of a double sided or jacketed vessel, holding about fifty gallons, constructed of boiler iron, and capable of withstanding considerable outward pressure. *a* is the outer case, *b* the edge of the inner vessel, in which the plaster is contained. The front is represented as partially removed so as to show the construction of the boiler. *c* is the wooden stirring spatula, which is attached to the beam, *g*, in a socket. *d* is the tube and cock by which the steam enters the jacket; *e*, a cock for the exit of the air at the

commencement of the process, and for drawing off the condensed

water from time to time ; *f* a wooden stand supporting the boiler, and *h* the surface of the plaster.

The usual charge for one operation in this apparatus, is fifteen gallons of oil and seventy-five pounds of litharge. The steam is employed under a pressure of eight or nine pounds per inch ; and in order to render the operation quicker, by keeping the temperature higher, the water necessary to the chemical change is added in small quantities at a time and frequently. The stirring is constant, and is effected with great ease by the stirrer, as represented in the figure. With this arrangement, the quantity of ingredients above stated are converted into plaster in two and a half to three hours.

The plaster made by steam heat is never burned, and when the materials have been good, the product has a light colour and proper consistence. Mr. Shoemaker is of opinion that lead plaster is injured in its quality of adhesiveness *per se*, as well as for the basis of other plasters, by washing and kneading in water to extract the glycerin, as recommended by many authorities, and he does not remove it unless with the direct object of obtaining that principle. When it is desired to isolate the glycerin, as soon as the plaster is completed, a considerable amount of hot water is poured in the boiler, and the whole again boiled up and stirred. By rest, the plaster separates, and the aqueous supernatant liquid contains the glycerin, holding in solution a little oxide of lead. To isolate the glycerin, the solution is evaporated to sp. gr. 1.15, a current of sulphuretted hydrogen passed through it until it ceases to produce a black precipitate, the solution filtered and boiled to rid it of excess of gas, and then evaporated at a very moderate heat until it ceases to lose weight.

When lead plaster is designed for adhesive plaster, it is more eligible to add the resin while it is yet in the boiler.

When completed, the plaster is removed from the boiler, in portions at a time, to a trough of cold water, which is kept cool by a current from the hydrant, and as soon as it acquires sufficient firmness to roll, is weighed off in half pound masses and rolled into cylinders on a wet marble slab. These are immediately placed in a long wooden trough containing cold water, so that they may cool before losing their cylindrical shape. It is usual to knead and pull light coloured plasters until their colour becomes decidedly lighter, either each roll separately, or several pounds together. Compound plasters, containing substances soluble in water, should not be cooled by that liquid, but should be chilled on a marble slab until fit to roll.

When the gum-resins are to enter the composition of plasters, it is

the oleo-resinous portion only that is desirable. It is better, therefore, to dissolve out this in alcohol .835 sp. gr., and evaporate it to a syrupy consistence, and admix it with the melted lead plaster, than to permit the gummy matter also to be introduced. When lead plaster and resin are to be combined, the former should be fused before the resin is added to it, as it has the higher fusing point.

When adhesive plaster is to be mixed with extracts, as that of belladonna, the mixture should be effected in a mortar, previously heated; the extract introduced and triturated till soft and homogeneous in consistence, and then the melted plaster should be added and the whole triturated until intimately mixed.

There is a kind of lead plaster that was formerly much in vogue, which was called burnt plaster. It is made without water; the litharge or red oxide of lead, either of which may be used, is heated in the fatty matter, which usually consists of oil and suet, and sometimes butter and wax were added, until the temperature rises to 400° or 500° Fahr. In making the *mother-ointment*, *onguent de la mère* of the French, the fats are heated in a capacious iron vessel, until they commence to fume, the litharge is then sifted in from a sieve, and stirred constantly.

The excessive heat decomposes the neutral fatty principles, liberates the oily acids, and renders them capable of union with the oxide. A part of the fat is decomposed, acetic acid and acrolein are produced, the latter remaining combined with oxide of lead as acetate.

The purely resinous plasters, as Burgundy pitch, hemlock pitch, or these mixed with other substances, do not require a notice here further than to observe, that in common with the true plasters they become lighter coloured by the process of pulling and kneading them while they are in a soft state.

The manner of spreading plasters, and other manipulations with them in extemporaneous pharmacy, will be noticed at length in Chapter XVII.—W. P.]

CHAPTER XV.

MISCELLANEOUS OPERATIONS, CHIEFLY OF A MECHANICAL NATURE.

STOPPERING OF GLASS BOTTLES.

It not unfrequently occurs that glass stoppers do not fit perfectly into the mouths of the bottles to which they belong. The best method of trying the fitting of a stopper is to press it down lightly with the point of one of the fingers, while it is pushed laterally in different directions. If it moves in any direction when thus treated, it must be considered as badly fitting, and unsuited for the preservation of volatile substances, or such as are readily oxidized or injured by exposure to the air. Even when liquids will not pass, the stoppering may admit of an interchange of the internal and external air, and this interchange is greatly promoted by the variations which are constantly occurring in the expansion and contraction caused by heat or barometric pressure.

Too much care cannot be taken to insure well-fitting stoppers for, at least, those substances which are most liable to change. If any are found to be defective, means should be adopted for remedying the evil.

Badly-fitting stoppers may be rendered air-tight by regrinding them. This is effected by first mixing sand or emery with water; then dipping the stopper into this, and placing it in the neck of the bottle, moving it laterally to and fro, with a gentle pressure, and slightly withdrawing the stopper from time to time to admit fresh portions of sand or emery. After grinding thus for some time, the stopper and the mouth of the bottle should be washed, and the fitting of the stopper tried in the manner already described. When the stopper is found to fit in firmly without shaking in any direction, the grinding may be finished off with a little fine emery powder and oil.

In this way, not only may badly-fitting stoppers be made to fit air-

tight into the bottles for which they were intended, but bottles not previously stoppered may have stoppers ground in to fit them. It is necessary in selecting a stopper to be thus fitted to a bottle, that due regard should be paid to the form of the neck of the bottle, for stoppers which do not agree in shape with the neck of the bottle can hardly be made to fit properly without the use of a lathe. If the neck of the bottle be more conical than the stopper, as shown in fig. 392, or if the stopper be more conical than the neck of the bottle, as shown in fig. 393, in either case it will be difficult, if not impossible, to make them fit well by mere hand-grinding. When long-continued

Fig. 392.

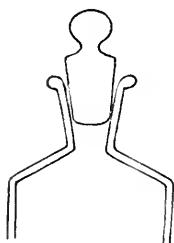


Fig. 393.

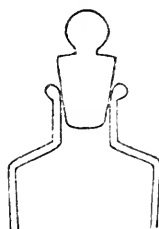
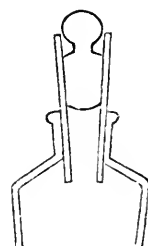


Fig. 394.



STOPPERING BOTTLES.

grinding is required, a piece of conical copper tube should be used in the process, with which both stopper and neck may be ground at the same time. The conical tube is made of a piece of sheet copper, bent and soldered to the proper form and size, and afterwards turned in the lathe so that the inner and outer surfaces may be perfectly smooth. This cone is used as represented in fig. 394, the stopper being placed within it, and the neck of the bottle on the outside. Copper answers the purpose better than any other metal, as the sand becomes imbedded in it, and thus forms a good grinding surface.

REMOVAL OF FIXED STOPPERS.

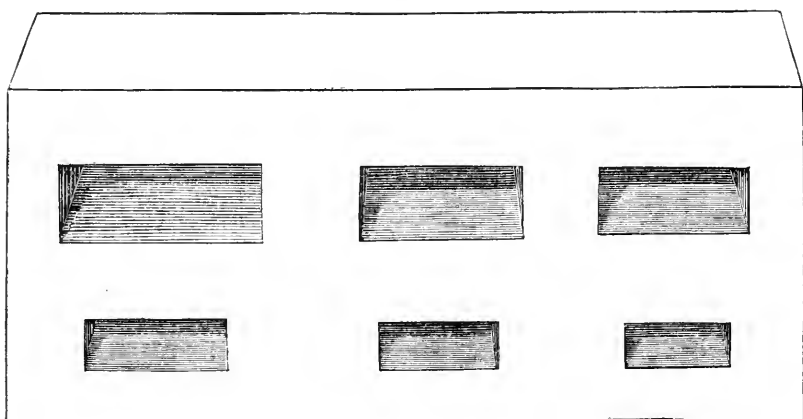
The adhesion of glass stoppers to the necks of bottles, from which they become immovable by the mere force of the hand, is a frequent source of annoyance to the pharmacist. There are several causes which give rise to the fixing of glass stoppers. Sometimes it is occasioned by the deposition of resinous or other adhesive matter between the stopper and the neck of the bottle, which, hardening there, forms a kind of cement; and sometimes salts are crystallized around

the stopper, either in consequence of the evaporation of a solvent, or from the sublimation of the salt itself. In some cases the pressure of the atmosphere, occasioned by contraction of the gaseous contents of the bottle, is the cause of the stopper becoming fixed; and this may either continue to operate directly in preventing the removal of the stopper, or having, by the force of the pressure, brought the stopper into very close contact with the neck, the adhesion may be thereby increased, and may then continue after the original cause has ceased to exist.

From these or other causes, glass stoppers are frequently found to be fixed, and the skill and ingenuity of the pharmacist are taxed for the means of extracting them. In some establishments, the extraction of the stoppers of smelling-bottles is, of itself, an operation of almost daily occurrence. The means of effecting the extraction must depend on the cause of adhesion, and on other circumstances connected with it, such as the size, form, thickness, &c., of the bottle, and also of the stopper.

If the bottle and its stopper be of sufficient capacity and strength, it is customary in the first instance to attempt the extraction by grasping the bottle firmly in one hand, and with the other hand push-

Fig. 395.



LEVER FOR REMOVAL OF FIXED STOPPERS.

ing the stopper laterally, in different directions, at the same time pulling it upwards. Should this method fail, the following may be tried. Hold the stopper between the fore-finger and thumb of the left hand, and press it upwards, while the other fingers rest on the shoulder or lip of the bottle, and then, holding a pellet-knife in the

other hand by its flexible blade, strike the stopper in a lateral and slightly ascending direction with the wooden handle of the knife. The blows thus inflicted, the force of which must depend on the strength of the stopper, and size of the bottle, should be repeated for some time, with the object of producing a vibratory motion in the bottle. Stoppers may frequently be extracted by this method with great facility, but it cannot well be applied to bottles of less capacity than half a pint or a pint. Sometimes a lever is used, which, fitting on to the stopper of the bottle, enables the operator to use more force than could otherwise be applied for overcoming adhesion. The lever consists of a piece of wood, fig. 395, in which there are several oblong holes of different sizes, into one of which the head of the stopper is to be put, a cloth being interposed between them, if this will make them fit better. The greatest possible care and judgment are necessary in the use of the lever, as the stopper may be very easily broken off by the force thus applied. Indeed, the cases are few in which this method can be safely resorted to, and there are probably many more stoppers broken than extracted by its adoption.

If none of the foregoing means prove effectual for the extraction of the stopper, the cause of adhesion ought to be considered. Should it be found that resinous or other matter soluble in spirit is the cause of the evil, it may be well to try the effect of placing a little alcohol in the groove between the stopper and the lip of the bottle, allowing time for this to be absorbed, and then repeating some of the methods previously described; or should the deposition of salt or other matter soluble in water, be the probable cause, a little water may be substituted for the alcohol.

More energetic measures may yet be found necessary, and, as a last resource, one or other of the following means should be adopted.

The application of the flame of a spirit-lamp to the neck of the bottle, constitutes one of the best and most uniformly successful methods. The immediate object in this case is, by the application of heat, to cause the expansion of the neck of the bottle, which will thus relax its grasp of the stopper, and allow the latter to be withdrawn. Some judgment is necessary in the application of heat. The whole of that part of the neck of the bottle which surrounds the stopper should be heated as uniformly as possible, without allowing the heat to be communicated to the stopper. The flame of the lamp should, therefore, be made to play over the part indicated, while the bottle is constantly turned so as to equalize the effect, and from time to time the extraction of the stopper should be attempted with the hand. The

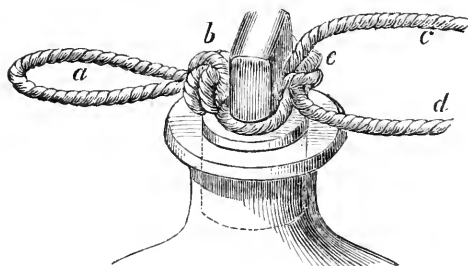
length of time required to produce the effect will depend on the size and thickness of the neck of the bottle. Should the bottle contain an inflammable liquid, the application of a flame may be unsafe, and in such case, a piece of cloth dipped into hot water may be wrapped around the part to be heated, and the heat maintained for the required period by pouring more hot water over it. This method of applying the heat, through the medium of hot water, is, indeed, under all circumstances, the safest and best way of conducting the operation.

But the above process, although very generally successful, if dexterously managed, in those cases where the size and form of the neck

Fig. 396.



Fig. 397.

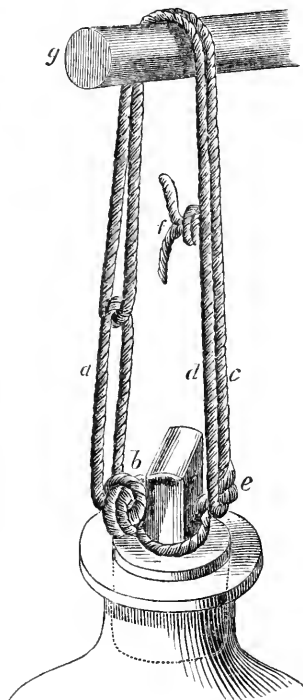


EXTRACTION OF FIXED STOPPERS.

of the bottle admit of the application of heat to that part, without, at the same time, heating the stopper, is, nevertheless, inapplicable in a great many instances, and especially in those of smelling-bottles, and of bottles generally of small size. In these cases the following will be found to be the best mode of proceeding.

In the first place, a strong cord, between three and four feet in length, is selected, which is to be tied to the stopper of the bottle. The cord is doubled, and tied in a knot near to the doubled end, as represented in fig. 396. This being done, the knot (b) is placed against one side of the stopper, and the ends (c, d) being carried along the groove to the opposite side, are tied there, as represented in fig. 397. The end (d) of the cord is now passed through the loop (a), and

Fig. 398.



the two ends being brought together, are tied as represented at (*f*) fig. 398. The cord being thus secured to the stopper, the bottle is, in the next place, to be suspended as shown in fig. 398, by placing the cord over the horizontal bar of sufficient strength and firmness to bear a powerful jerk. It must be so adjusted that the cords on each side of the stopper shall be of equal length, and the weight of the bottle will then insure its maintaining a vertical position. An assistant places his hand over the part of the cord in contact with the horizontal bar, to prevent it from slipping to either side, and the operator, having wrapped a cloth around the neck and shoulder of the bottle, and grasped this part with his two hands, raises the bottle a few inches, and then pulls it down with a jerk. This operation is repeated, commencing with slight force, and increasing the power with each successive jerk, until the extraction of the stopper is effected. If care be taken to maintain the vertical position of the bottle, and of the direction of the jerk, there will be little danger of breaking the stopper. I have found this a more effectual method of extracting the stoppers of smelling-bottles, and of small bottles generally, than any other that I am acquainted with.

DESICCATION OF BOTTLES, FLASKS, ETC.

The pharmacist has frequent occasion for drying glass vessels expeditiously. The bottles into which oils, syrups, and some other substances are put, should always be made perfectly dry, after washing them, before they are used for the purposes intended. Vessels having only one orifice, and that a contracted one, do not readily part with their moisture, unless a particular arrangement be adopted for promoting desiccation. Many days or even weeks would elapse before a bottle, which has been just rinsed with water, would become perfectly dry if it were merely exposed in a dry room at the mean temperature of the atmosphere. To insure rapid desiccation a current of warm air should be made to pass through the vessel.

The best method of proceeding is, to warm the vessel, by placing it on a sand-bath, or in some other warm situation, and then to blow into it with a bellows. The warm air loaded with moisture, is displaced by a current of comparatively dry air, which becoming heated from contact with the vessel, is capable of taking up and carrying away some of the moisture which remains. By operating in this way, and repeating the application of heat and the blowing as often as is necessary, complete desiccation may be very speedily effected. It is neces-

sary, however, to observe that the vessel not only appears to be dry while it is warm, but that this continues to be the case after it has cooled; for moisture which the air holds in solution when warm is sometimes deposited again as the temperature falls.

In the absence of a suitable bellows a glass tube and the human lungs might be used with similar effect, although in this case the desiccation would not be so rapid. The tube should be long enough to reach to the bottom of the vessel, while it projects some inches above the orifice. After heating the vessel as previously described, the tube is introduced, and the operator, having exhausted his lungs, applies his mouth to the end of the tube and makes a long inspiration. The moist air of the vessel is thus drawn into the lungs, and dry air from without enters to supply its place. The process is repeated in this way until the vessel is completely dried.

Tubes, when sealed at one end are dried in the manner above described. If they be open at each end the desiccation is much more easily and quickly effected. It is then only necessary to hold them in an oblique position over the flame of a lamp or other source of heat. A current of air will thus be determined upwards which will soon carry off the moisture.

ON TYING KNOTS.

There is some art involved even in the tying of a string, and inconvenience is not unfrequently occasioned by a badly constructed knot. The common method of tying a knot for securing the ends of a string, is sufficiently well known; but there are a variety of circumstances under which knots of different kinds are required, and the best methods of making these are not so uniformly understood.

In some cases it is more important to be able to fasten the string expeditiously than very securely; in other cases the tightness of the compression is the object principally aimed at; in others, again, close compression, secure fastening, and the means of subsequently tightening the knot, are desired.

The capping-knot.—In capping bottles, it is sometimes advantageous to adopt a more easy and expeditious mode of fastening the string than by making a common knot. This is especially the case in capping draughts, and small vials generally, for as both hands are necessarily occupied in making the common knot, there is some difficulty in keeping a small vial in a suitable position during the opera-

tion. The *capping-knot* is both easily and expeditiously made. The vial is held in the left hand, and the end (*a*, fig. 399) of the string is placed under the thumb, while, with the other hand, the string is carried twice round the neck of the bottle; it is then formed into a

Fig. 399.

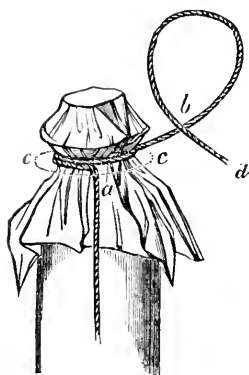
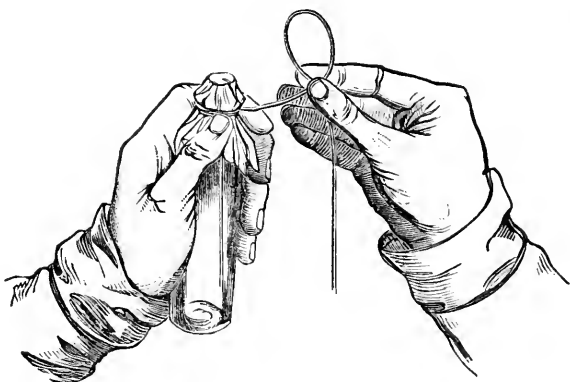


Fig. 400.



THE CAPPING-KNOT.

loop, as represented in fig. 399, and this loop being held at (*b*) between the thumb and fore-finger, is thrown over the top of the bottle and brought to the position of the dotted line (*c c*), so as to pass over and compress the end (*a*) of the string; finally, the end (*d*) of the string is pulled so as to form a knot, which is sufficiently secure for the purpose intended. Fig. 400, shows the method of holding the vial and string in making this knot. Vials may be capped in this way in half the time that would be occupied if the common knot were made. But the *capping-knot* can only be used advantageously in capping bottles which have short necks and projecting lips, such as the smaller description of vials have. Green-glass moulded bottles of six ounces capacity and upwards require to have the caps tied on with a more secure knot.

The binding-knot.—In fitting together glass tubes with India-rubber connectors, it is generally found necessary to bind the latter with a silken or other cord, so as to render the juncture air-tight. In doing this, it is difficult to secure the ends of the cord with a common knot, without at the same time relaxing the tightness of the compression. *The binding-knot* affords a ready method of forming a perfectly tight and secure ligature. It is made in the following way. The end of the string is doubled, and laid on the tube, as shown in fig. 401, *d* being the short end, and *c* the long end of the string. The tube being held in the left hand, the thumb of that hand is laid over the

loop (*a*), so as to retain it in the position represented, while *c* is carried round the tube several times, and, finally, is passed through the end of the loop (*a*), as shown in fig. 402. The end (*c*) being held tightly in this position, the other end (*d*) of the string is pulled so as to reduce the loop (*a*) until it clasps (*c*) and securely fixes it. The ends (*c* and *d*) are now cut off, leaving the ligature as represented in fig. 403.

Fig. 401.

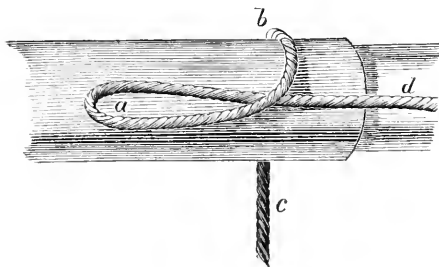


Fig. 402.

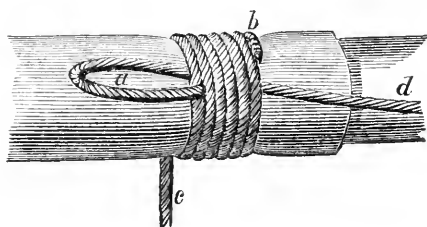
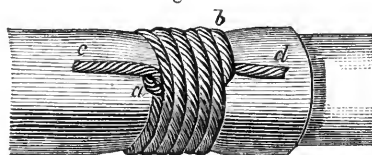


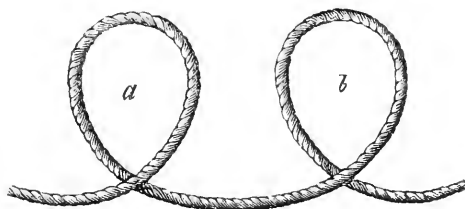
Fig. 403.



THE BINDING-KNOT.

When the coils are brought close to each other and made tight by drawing the ends in opposite directions, a pretty secure knot is produced. Sky-rockets

Fig. 404.



THE PYROTECHNICAL KNOT.

are tied in this way, and hence the name. A few coils of the string

forms a good ligature for an India-rubber connector ; and it has these advantages, that it may be tightened at any time by pulling the ends,

Fig. 405.

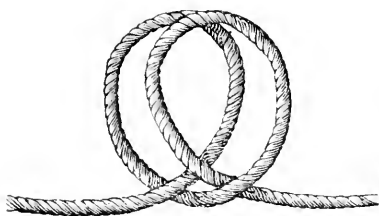
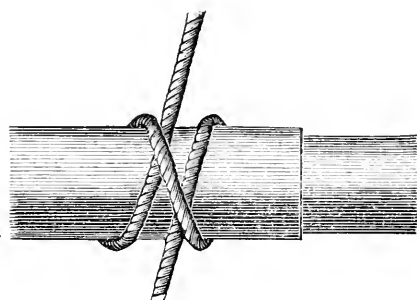


Fig. 406.



THE PYROTECHNICAL KNOT.

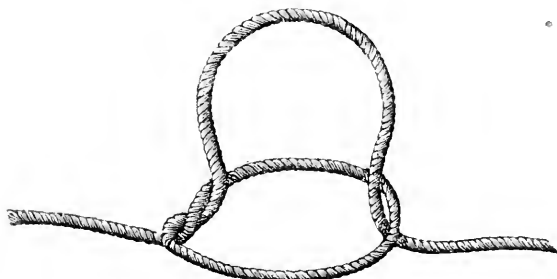
and also, that it may be easily untied, without cutting the cord, by merely pulling each ligature away from that next to it.

The beer knot.—The corks of bottles are sometimes fastened down with string, which is tied in what is called a *beer knot*. The name is

Fig. 407.



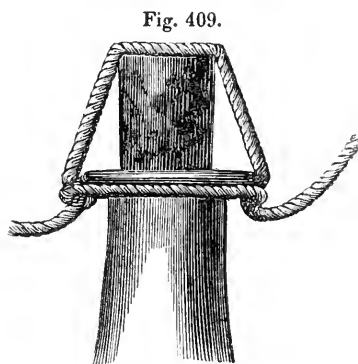
Fig. 408.



THE BEER KNOT.

probably derived from the application of this knot in tying down ginger beer. It is thus made:—First, the loop, fig. 407, is formed ;

then the part of the string which passes across the loop is turned up, as in fig. 408. This is placed over the cork of the bottle, and by dexterously pulling the two ends, the loop is made tight beneath the lip of the bottle, while the string which crossed the loop passes over the top of the cork, as represented in fig. 409; the ends are then tied at the top.



THE BEER KNOT.

The champagne knot is also used for fastening down the corks of bottles. It is a more secure knot than the beer knot. A loop, such as fig. 410, is first formed; then the end (*m*) is turned into the angle (*o*) and carried behind or

Fig. 410.

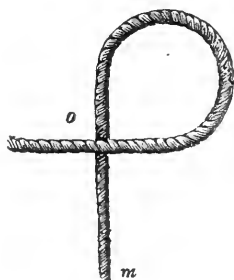
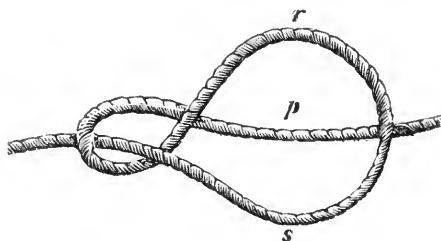


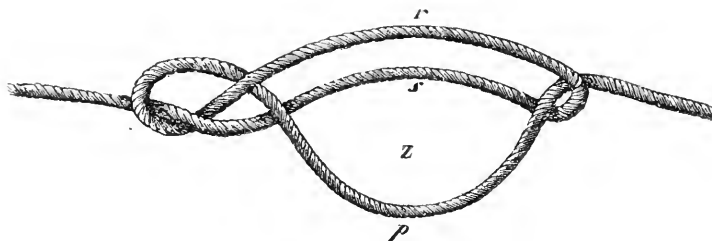
Fig. 411.



THE CHAMPAGNE KNOT.

beneath the loop, as in fig. 411. The part (*p*) is drawn through the loop, as in fig. 412, and in this state it is placed over the neck of the

Fig. 412.



bottle immediately under the lip; *p* being on one side, and (*r s*) on

the other side. The two ends are then pulled so that, the knot being tight around the neck of the bottle, the free ends shall be opposite

Fig. 413.

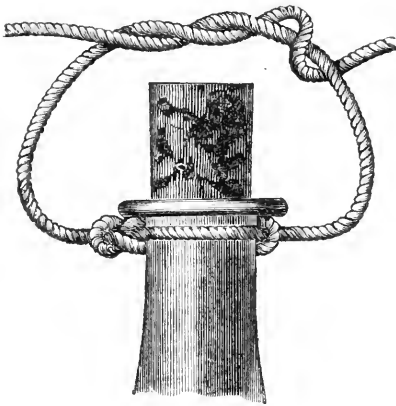
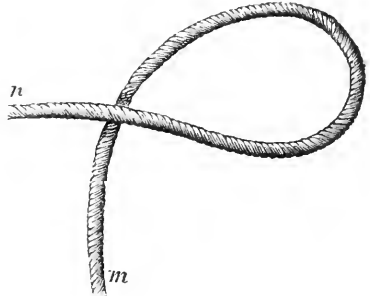


Fig. 414.



each other, and these are turned up over the cork, twice twisted, and finally tied in a common knot, as shown in fig. 413.

There is another more simple, but less secure, method of making

Fig. 415.

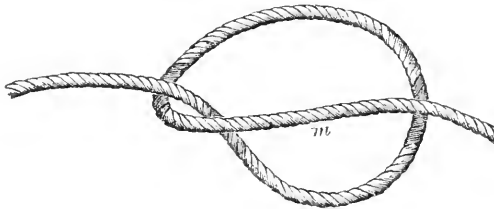
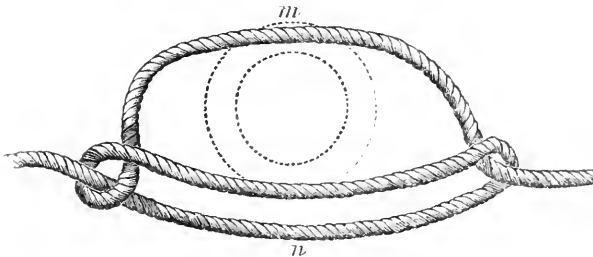


Fig. 416.



THE CHAMPAGNE KNOT.

the champagne knot, as follows :—the loop (fig. 414) is first formed, then (*m*) is carried across the loop in front, as in fig. 415, and being

brought out on the other side (fig. 416), it is thus slipped over the neck of the bottle and tied as in the other case.

CUTTING, DRILLING, AND BENDING GLASS, ETC.

There are several operations connected with the modification or construction of glass vessels and apparatus, which the pharmacist has frequent occasion to perform. Among these are the operations of cutting, drilling, and bending glass.

In cutting glass the method to be adopted will depend on the form, size, and thickness of the part to be cut. If it be cylindrical and tolerably thick, the iron ring (fig. 417) may be used. This instrument consists of a round iron rod, the two ends of which are bent so as to form two circles of different sizes. It is used in the following manner:—The ring which most nearly fits to the cylindrical glass to be cut is put into the fire until it has become red-hot; it is then placed around the glass where the separation is desired, and kept there for a few minutes; on removing it, a few drops of water are allowed to fall on the heated part, when it will instantly split in two. The principal objection to this mode of operating is that, for its complete success, it is necessary that the iron ring should very nearly fit to the part to be cut. If the ring be much larger than the glass, it must be made to approach alternately on every side, and as the heating is never so uniformly effected in this way as it would be otherwise, the fracture will sometimes be irregular. With a suitable ring, the operation may be well and expeditiously effected, and it is particularly applicable for cutting off the ends of the necks of retorts or of flasks.

Fig. 417.



IRON RING FOR CUTTING GLASS.

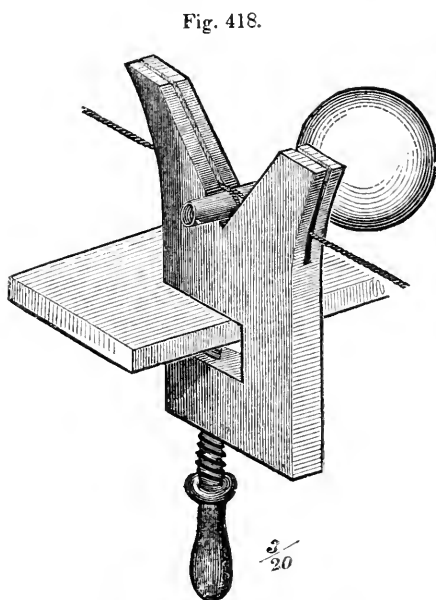
A method is sometimes adopted, which consists in tying a thread of lamp-cotton, dipped in oil of turpentine or in sulphur, around the part where the fracture is required, then igniting the thread, and when the flame has heated the glass, dropping a little water on to it. This method seldom succeeds well, as the flame heats too wide and unequal a surface.

Another and much better method of effecting the same object is, to heat the glass by the friction of a string passed around it, and drawn to and fro with great rapidity. In doing this it is necessary to have

some means for confining the string to the exact part required to be cut.

One method of confining the string is to bind a thick cord, in the manner represented in fig. 403, around the glass, on each side of the part to be cut, leaving a groove just wide enough for the string by which the friction is effected to run in. One end of this string is to be fastened to some firm object, and a single coil being carried round the glass in the groove, the other end is to be held in the hand of the operator or of an assistant. The glass is now to be drawn alternately towards each end of the string, increasing the velocity of the motion to the greatest extent practicable, and continuing the friction for two or three minutes; it is then to be plunged into a vessel containing cold water, when the fracture will instantly occur.

Fig. 418, represents a good arrangement for confining the string.



ARRANGEMENT FOR CUTTING GLASS.

In this case a piece of board is used, in which there is an angular notch, giving it somewhat the form of a boot-jack. This board is fixed to a table, while the notch receives the cylindrical glass to be cut, as shown in the drawing. There is a groove or slit in the board extending as far as the notch, through which the string passes. The glass, having a coil of the string around it, is kept in a fixed position in the angle of the notch, while two assistants draw the ends of the string alternately in opposite directions. The friction is thus confined within the narrowest possible limits. If the operator

can hold the glass in his left hand, he may draw one end of the string with his right hand while an assistant draws the other end. It is necessary to avoid the application of any grease to the cord or to the glass during this operation, as the friction would be thereby diminished.

If the size, form, or thickness of the glass be such as to prevent the successful application of the foregoing methods of operating, the ignited pastil, or charcoal point, might be advantageously used.

Pastils are prepared expressly for cutting glass, being made of a composition somewhat analogous to that of the common fumigating pastils, which is rolled out into pointed sticks. Gahn has given the following formula for these pastils. Dissolve $2\frac{1}{2}$ ounces of gum arabic, and $\frac{1}{2}$ ounce of tragacanth, in $5\frac{1}{2}$ ounces of water. Dissolve $\frac{1}{4}$ ounce of styrax, and $\frac{1}{4}$ ounce benzoin in $1\frac{1}{2}$ ounce of spirit. Mix the two solutions with $3\frac{1}{2}$ ounces of powdered charcoal, or as much as is sufficient to form a tough paste. This is formed into sticks about the size of a black-lead pencil, which are subsequently dried. I have found the following more simple formula to answer equally well. Reduce half an ounce of powdered tragacanth to an elastic mucilage with a sufficient quantity of water, allowing them to macerate together for about an hour; then add a quarter of an ounce of benzoin dissolved in spirit; rub them together in a mortar, and mix in as much powdered charcoal as will form a tenacious paste. Before rolling the mass into sticks, it should be well pounded, and made rather soft, otherwise it will crack, or the sticks will become hollow in the centre, in which case they will not burn to a point.

In using the pastil for cutting glass the usual method of operating is, to lead a crack, previously commenced, in the direction in which the fracture is required. If the vessel to be cut has already a crack, a line should be drawn beneath it, with chalk or ink, and carried round the vessel. The pastil is now to be ignited at the point, and the incandescent part applied to the end of the crack and slowly moved in an oblique direction towards the line, so that it may pass into the marked course at an angle of about forty-five degrees. The crack will follow the burning point as it is thus made to pass over the surface of the glass, and may be carried round the vessel in the direction required. Should there be no previous crack, a scratch is first made with a file in a slanting direction, and on applying the burning pastil to this, a crack will be formed, which may be led in the manner already described. Fig. 419 represents the way in which this is done. It is generally safer to commence the crack from the upper edge of the vessel than from any point below it.

Badly annealed glass, and vessels which are not circular, cannot be cut in this way with any certainty; but if the glass be tolerably thick and well annealed, the crack will often be as straight and smooth as if cut with a diamond.

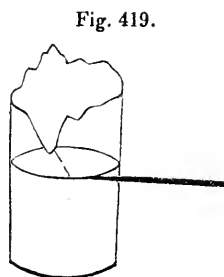


Fig. 419.

CUTTING GLASS WITH A
CHARCOAL POINT.

The sharp angles of the cut edge should be taken off with a file wetted with oil of turpentine; and should there happen to be any inequalities in the surface formed by the fracture, these may be removed either by the file or by rubbing the part over the surface of a sandstone.

The file is often used alone, for cutting glass, especially glass tubes, which are most conveniently cut in this way. A scratch is made on one side of the tube at the part to be cut, and the tube being then held in the two hands of the operator on each side of the scratch, it is gently strained in a lateral direction, while at the same time it is pulled longitudinally.

The boring or drilling of glass is an operation not very frequently required to be performed, yet it is well to understand how it is done. Round holes are cut into glass vessels with copper cylinders, which are about two inches and a half in length, and of any required width up to three quarters of an inch in diameter. These cylinders are made of sheet copper, about one line in thickness. They are fixed upon a block in the turning lathe, where the sides and edge are made smooth and fit for cutting. A circular piece of paste-board is cut to the size of the interior of the cylinder, so that it should fit in loosely, and this is fastened with paste or glue over the spot where the hole is to be cut in the glass. This paper disk is intended for guiding the cylinder, and preventing it from slipping about, while it makes the first incision. A stand must now be provided for the glass, so that the part to be drilled shall be exactly opposite the copper cylinder. These arrangements being made, a rather thick mixture of emery powder and oil is applied to the edge of the cylinder, and the glass being placed against it, the lathe is put into motion. A circular groove is thus speedily cut around the circumference of the pasteboard patch, over which the cylinder is placed, and by which it is retained in its proper place. The glass should be occasionally withdrawn a little from the cutting instrument and again made to approach it, and the supply of emery from time to time renewed. It is necessary towards the end of the operation to be careful that the cylinder when it has cut the groove completely through the glass should not be pressed forward so as to break the vessel. The pressure should be cautiously adjusted by the hand, until the piece breaks out, and the cylinder should then be instantly withdrawn. Under these circumstances, there will generally be a rough projecting rim on the inner edge of the cut surface, from which the cut piece has fallen, and this will prevent the cylinder from passing in. This projecting edge is to be ground off with a file.

In this way round holes may be cut into the sides of thick bottles, so that stop-cocks or tubes may be inserted through perforated corks.

When holes of smaller diameter are required to be made, the operation is performed with a common drill and bow-string, such as fig.

420. The surface of the glass

should be broken at the spot

where the hole is to be made,

with the end of a sharp file or

with a scratching diamond;

and the point of the drill, pre-

viously wetted with oil of tur-

pentine, is then placed upon

the spot and worked with the

bow. It is essential that the

part should be kept constantly

wetted with the turpentine,

which has a peculiar efficacy

in promoting the abrasion of the glass, and at the same time the pro-

tection of the steel instrument. The efficacy of the turpentine will

be increased if it be slightly resinified by exposure to the air, or even

if it be thickened by dissolving a little common resin, or camphor in

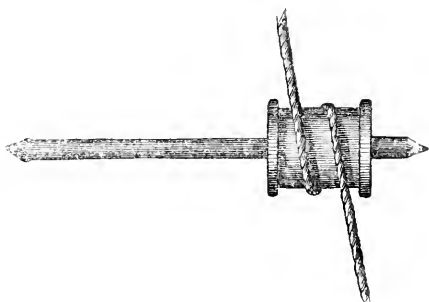
it. In all cases where glass has to be cut with a steel instrument oil

of turpentine should be used.

The bending of glass tubes is an operation of constant occurrence in connexion with the fitting up of apparatus.

The first point claiming attention in reference to this operation is the selection of suitable tubes. The glass of which the tubes are made should be easily fusible, so that they may admit of being bent, drawn out, or sealed, in the flame of a lamp. It is important that the thickness of the glass should bear a certain relation to the size of the tube, for if it be too thin, the tube will collapse at the bend, and, moreover, when passed through a cork, it will not admit of the necessary compression to render the juncture air-tight, without some danger of the tube being broken. A tube, the external diameter of which is five lines, should have a thickness of glass of about three-fourths of a line, as fig. 421. This is a very suitable size for conveying gases. Tubes of smaller diameter, such as fig. 422, which is four lines in diameter, and half a line in thickness of glass, are used for small appa-

Fig. 420.



DRILL FOR BORING GLASS.

Fig. 421.



Fig. 422.



Fig. 423.

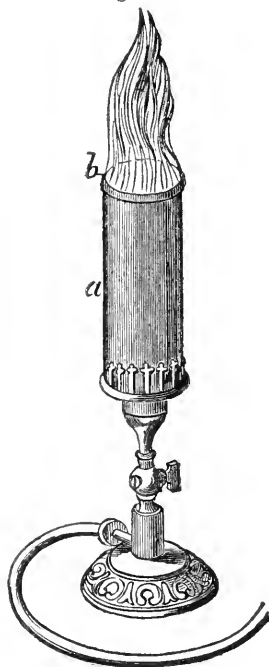


ratus. If tubes of larger diameter are used, the thickness of the glass should be in proportion. Fig. 423 represents a size seven lines in diameter and one line in thickness, which is suitable for the distillation of ethereal and other liquids, the vapours of which require free means of escape.

A tube suitable for its intended application having been selected, the bending is effected with the aid of the flame of a lamp.

The flame of a *common Argand gas-burner* may be used with a short copper chimney, the height of the chimney being such that the flame extends about an inch above the top of it.

Fig. 424.



SOLID GAS-FLAME.

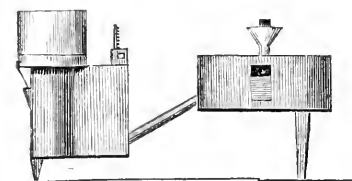
The solid gas-flame (fig. 424) is very suitable for bending glass tubes, especially if they be large and thick. The arrangement by which this flame is produced is similar to that of the mixed gas-furnace, figs. 1 and 3, page 20. It consists of a common gas-burner, over which is placed a copper cylinder (a), with a wire gauze top (b). The gas is allowed to escape from the burner, and, mixing with atmospheric air in the copper cylinder, the combustible mixture issues through the wire gauze at the top, and burns there with a solid pale-blue flame, from which there is no deposition of charcoal.

In the absence of gas, a *spirit-lamp with double draught* (fig. 425) will be found fully efficient for the purpose required.

The lamp having been prepared, the part of the tube which is required to be bent should be marked with a piece of chalk, and the

tube should then be held over or introduced into the flame. If the glass be thick, the part at which the bend is to be made, and extending for an inch or two on each side of it, should be gradually warmed by holding it above the flame, and moving it to and fro, while at the same time it is turned on its

Fig. 425.



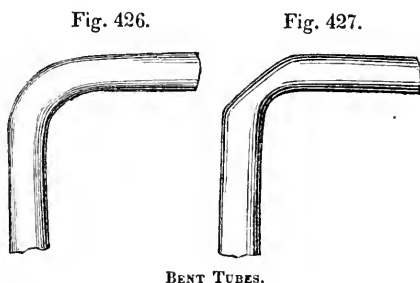
SPIRIT-LAMP WITH DOUBLE DRAUGHT.

axis so as to equalize the effect. It may then be brought into contact with the flame, still continuing to move it as before. When slight indications of softening are perceived, which the hand of an experienced operator will readily discover, one end of the heated part is to be kept in the flame, the tube being merely turned on its axis, and not moved to and fro, until it admits of being bent with a slight force; the rotating motion is then stopped, while a slight curvature is given to this part; the tube is then moved so as to bring another heated portion into the flame, which in like manner is slightly curved; and this is continued until the curve extends to an equal distance on each side of the chalk-mark, and until the two limbs of the bent tube form the required angle. It will be found convenient to have some object in front of the operator to assist the eye in determining the required angle. The bars of a window may be conveniently used for this purpose when a right angle is required, the bent tube being held before the eye and brought opposite to, or parallel with, two intersecting bars. In making the bend while the heated part of the tube is in the flame, the ends should always be turned upwards, and not in any other direction.

By proceeding as above described, a uniform curve may be formed, such as fig. 426, which represents a good bend, while fig. 427 represents a badly-formed curve, such as inexperienced operators generally produce.

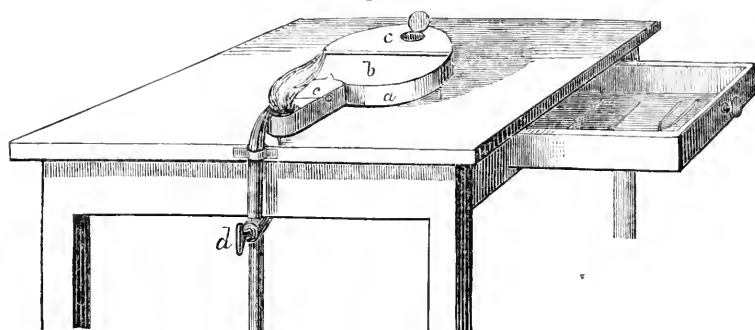
To get a good curve, it is desirable that the heat should not be confined to one point, and that the glass should not be softened more than is ne-

cessary to admit of its being bent. A large flame, and especially the solid gas flame, fig. 424, will be best adapted for producing the effect required. If the heat be too much confined to one spot, and the glass be much softened, the tube will collapse in bending, as shown in fig. 427, a result which should always be avoided if possible. It is necessary, however, in addition to the precautions already mentioned, that the glass should have a certain thickness in proportion to the diameter of the tube, equal, or nearly so, to that indicated in figs. 421, 422, 423. If the tube be large and the glass thin, it will be very difficult, if not impossible, to prevent it from flattening on the outer side of the curve, and not only will the glass, when thus bent, be very likely to crack, but the tube will be contracted at this part. When it is im-



portant to avoid the collapsing of a tube, which, from the thinness of the glass or some other cause, will not admit of a good curve being

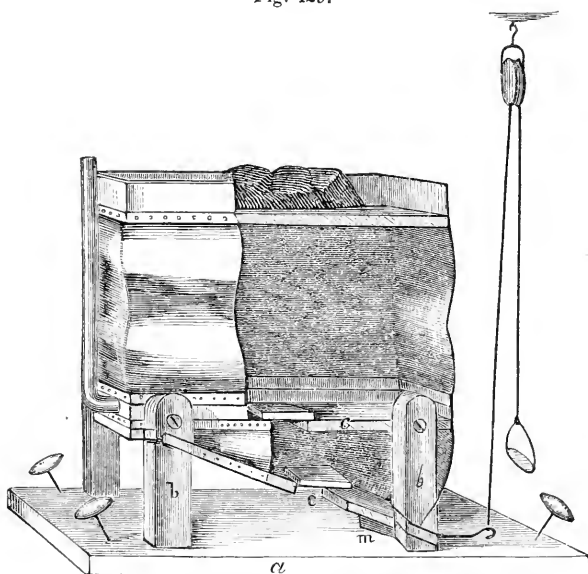
Fig. 428.



GLASS-BLOWER'S BLOWPIPE.

formed in the manner above described, the best method of proceeding will be, to seal one end of the tube, and then, after bending it, and while the glass is still soft, to blow into it from the other end. The increased elasticity of the air, caused by blowing, will force out the

Fig. 429.



BELLOWS FOR BLOW-PIPE.

compressed part of the tube and restore its cylindrical form to it. This is the method usually adopted by the glass-blowers.

There are some operations on glass tubes, in performing which a stronger heat than that of a common lamp is required, and in these cases the blowpipe is employed. Thus, for instance, in drawing out and hermetically sealing glass tubes, excepting in the case of small tubes, it is necessary to have the intense heat of the blowpipe. Fig. 428 represents the usual arrangement of the glass-blower's blowpipe. The lamp (*a b c*) stands on a table, in front of which the pipe (*d*) conveys the compressed air from a bellows. The glass-blowers generally prefer the flame of an oil-lamp to that of a gas-lamp. The bellows, fig. 429, stands beneath the table, and is worked by the foot of the operator placed in a stirrup. The best method of constructing the bellows has been already described at page 84.

[“The most convenient form of apparatus for working glass on a small scale, is the water blowpipe, which consists of an upright box, about fifteen inches high, of the form represented in fig. 430. It is usually made of zinc or copper, and is divided into two compartments by the plate *a*, which passes down to within half an inch of the bottom, thus leaving a communication open between the two. The lower end of the tube *b* is closed by a valve opening outward to prevent the escape of air in that direction. The box should be filled about half full of water, and when used, air is blown through the tube *b*. The pressure thus occasioned in the compartment *c*, forces a portion of the

Fig. 430.

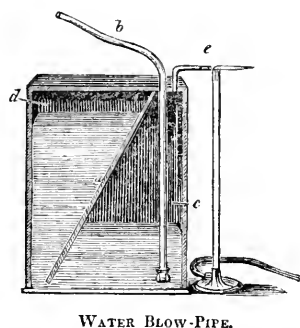
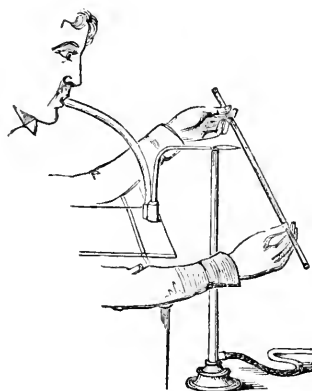


Fig. 431.



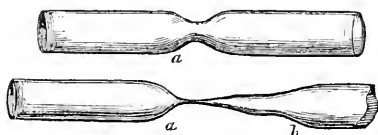
water into the next division *d*, where it rises to a higher level than in *c*. In this way a continuous jet is readily obtained, with much less fatigue to the operator than with the mouth blowpipe.” The manner of using this apparatus is shown at fig. 431.—*Bowman's Chemistry*.—W. P.]

In drawing out glass tubes, the part to be operated upon is first warmed by holding it over the flame; it is then heated strongly by directing the flame upon it, while the tube is constantly turned, so that it may be equally softened on every side. When it is found to admit of extension, it is drawn out to the required extent. If the object be to get an extension of tube with a uniform but contracted diameter, the softening should be effected through a part of the tube two or three inches in length, and it should be drawn out slowly and steadily before it has become very soft. If, on the other hand, it be desired to have a gradual contraction, the part softened may be shorter, the softening should be carried further, and the drawing effected more rapidly.

As the drawing out of the tube makes the glass thinner, it is sometimes desirable to thicken the softened part before extending it. This is done by pressing the two ends towards each other, while the softened part is in the flame.

The sealing of glass tubes is effected in a somewhat similar manner to that last described. The part intended to be sealed is first drawn out. If the sealing is to be effected at the end of a tube, another tube of about equal diameter is put into the flame with it, and when sufficiently softened, these are to be united together by fusion, then rapidly drawn out, (as at fig. 432,) and the fine point at which the

Fig. 432.



two parts separate, put into the hottest part of the flame, until it fuses into a globule. When the sealed end is required to be suddenly contracted, the softened part of the tube should be short; it should be much

softened before drawing it out; and the part to be sealed should be kept steadily in the flame while the extending part is drawn away from it.

For producing a round and smooth bottom, such as that of a test-tube, after sealing the tube as above described, the sealed end is again softened in the flame, and a piece of thin tube being united to it by fusion, the point is drawn away. The sealed end is then uniformly softened and air blown in from the open end, while the tube is rapidly turned round [until it assumes the uniform curve of fig. 433]. In this way, only softening rather more of the tube, a bulb may be blown at the sealed end.

Fig. 433.



[After the sealing is complete, the open end of the tube is heated

and spread into a lip, as at fig. 434, the tube being turned in the left hand whilst the edge is flared by means of a piece of smooth iron wire.

Fig. 434.

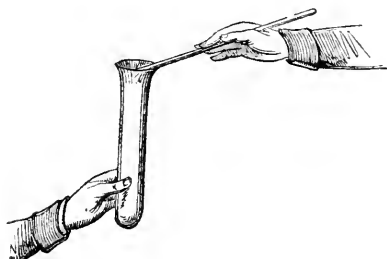


Fig. 435.



Sometimes it is desirable to join two pieces of tubing, by fusing them together. When of equal diameter, and rather thin, the ends, which should be uniformly smooth, are each slightly flared, as at fig. 435. The edges are then brought to a red heat in the flame of a blowpipe, and pressed together until they unite all round. In performing this simple operation, much dexterity is required to prevent the tube from being misshaped by too great pressure. As soon as the union is effected the pressure should cease, and the operation completed by turning the joint in the flame, near its point, until the fusion is complete. If, owing to too much heat, the joint has contracted to a less diameter than the tube, if both ends are open, close one end with a cork, and after heating the joint uniformly, blow gently into the tube until the contraction is expanded.

When the tubes to be joined are of unequal diameter, the larger one is drawn out until its diameter corresponds with the smaller tube,

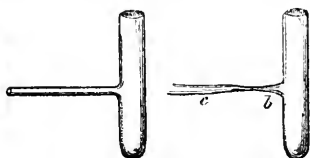
Fig. 436.



Fig. 437.



Fig. 438.



when it is cut off with a file. The smaller tube is then widened slightly, so as to overlap the contracted end of the larger tube, as in fig. 437. The two tubes thus arranged, are placed in the flame until cemented at one point, when they are turned constantly in it

until the fusion is effected at all points; if undue contraction has occurred, it can be remedied as stated above. This mode of cementing is resorted to to form the tube-funnel (fig. 436), and the pipette glass, fig. 185. When a large bulb is wanted with a small tube attached to either side, a short piece of thick large tube is drawn out at both ends, and small tubes attached to it, as at fig. 437. When the large tube, having been properly heated, and one of the small tubes closed, the operator blows into the other tube, constantly turning it until the bulb is formed.

When it is desirable to attach a small tube to the side of a larger one, and opening into it, as, for instance, in attaching the lateral tube to a syphon, the end of the larger tube is either sealed, as in fig. 438, or stopped with a cork, the flame of the blowpipe directed against the point *b* till properly softened, and then by means of a point of glass, *c*, the part is drawn out, as in the figure. By means of a file, the protruded glass is cut at *b*, and the end of the small tube is widened to fit over. The two parts are then brought to a proper heat, gently pressed together, and then thoroughly joined by fusion, the lateral tube being subsequently bent to the proper position.

In blowing a bulb on a tube, the tube should be rather thick, and

Fig. 439.



if the bulb is not to be large, after sealing the tube, about half an inch of its length is brought to a red heat, when the operator blows into the open end, as at fig. 439, holding the tube horizontal and turning it constantly. The perfection of the bulb depends on the uniformity of the temperature of the expanding glass, and the steadiness of the motion of the tube, and of the pressure within.

When a tube is to be sealed hermetically, as in closing a hydrometer tube after the graduation is finished, the edges are approximated by softening the glass, until all but a very minute orifice is closed. The point of the flame is then directed to this part, until the orifice closes by fusion. When, however, the sealing can be effected by drawing out, after the introduction of the substance, the glass is softened and drawn out to a thread, as at fig 440. When cool, it is cut at *a*, and the orifice closed by a jet of flame. We are indebted to Bowman's Chemistry for several of the above illustrations of glass-working. To those who are desirous of becoming familiar with this artificial accomplishment, the little work

Fig. 440.

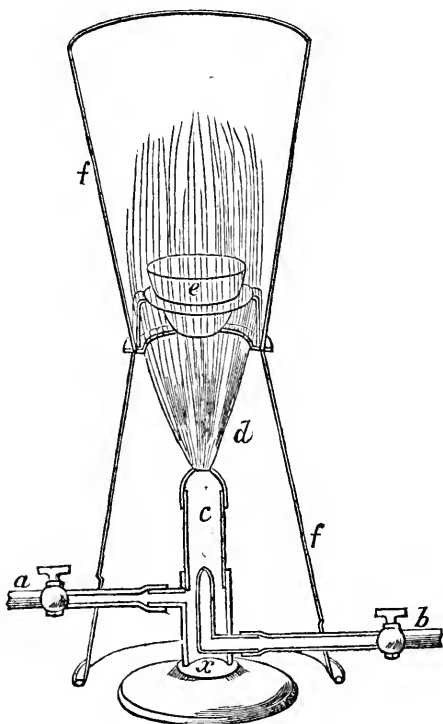


closed. The point of the flame is then directed to this part, until the orifice closes by fusion. When, however, the sealing can be effected by drawing out, after the introduction of the substance, the glass is softened and drawn out to a thread, as at fig 440. When cool, it is cut at *a*, and the orifice closed by a jet of flame. We are indebted to Bowman's Chemistry for several of the above illustrations of glass-working. To those who are desirous of becoming familiar with this artificial accomplishment, the little work

of T. P. Danger, on the "Art of Glass-blowing," of which an English translation exists, strongly recommends itself.—W. P.]

In performing operations on glass tubes, when a strong heat is required, the *gas-blowpipe*, fig. 441, may be used advantageously. Blowpipes constructed on this principle have for many years been used at Birmingham in brazing large vessels. The form represented in the drawing is that which I have adopted, and found suitable for chemical purposes. To a circular stand (*x*) is fixed a brass cylinder (*c*), which is slightly contracted at the top or mouth. A pipe charged with common coal gas, and furnished with a stop-cock (*a*), enters this cylinder on one side; and a pipe (*b*), connected with a good double bellows, enters on the opposite side, and terminates with a small orifice in the centre of the cylinder. This pipe also has a stop-cock.

Fig. 441.



REDWOOD'S GAS-BLOWPIPE.

In using this blowpipe, the gas is turned on at *a*, and ignited at the mouth (*d*) of the cylinder. The stop-cock (*b*) is then opened, and a blast of air forced into the centre of the cylinder by the bellows. This air mixing with the gas forms a combustible mixture, which issues at the orifice under pressure, and forms a spreading flame, the heat of which is very intense. The proper proportions of gas and air are adjusted by the stop-cocks, so as to afford a pale blue flame, from which there is no deposition of carbon. I am accustomed to use a furnace (*ff*) for confining the heat, and applying it to a crucible, as represented in the figure. The furnace, of which the drawing represents a section, consists of two conical cylinders united at their smaller ends. It is placed over the blowpipe, two apertures being provided

for the tubes *a* and *b*. There is a rim, projecting inwards at the part where the two cones are joined, which serves to receive a stand for a crucible, as shown in the drawing.

[*Graduation of glass vessels*.—The measures employed in the ordinary business of the shop are rarely graduated by the pharmacist, being provided by the artists in glassware; but the manner of graduating these, as well as tubes and other vessels, should be known to him. Graduating, so far as ascertaining the quantities is concerned, is performed either by measuring or weighing certain equal quantities, and adding them consecutively to the vessel to be graduated, making a mark on the side of the vessel opposite the level, after each addition. For druggists' graduates, the most eligible apparatus is the *graduating syringe*. This consists of a brass barrel or cylinder, capable of holding two or three fluid ounces, and placed horizontally on a frame at the height of ten inches. The piston is made solid, is nearly the length of the barrel, and fits very accurately, so that there is no possibility of the contained fluid passing it, and collecting in the rear. The piston-rod works in a guide, and is accurately graduated into degrees, indicating quarter drachms, half drachms, and drachms. The point of the syringe is curved downwards, at right angles to the barrel, and has a small orifice. In using it, the operator displaces all the air in the syringe with water, places the vessel to be graduated under the point, and carefully expels the contained water in quantities to suit the degrees he proposes to place on the measure. The glass should either have a strip of paper with a black edge, pasted vertically on one side, or a delicate mark with a scratching diamond should be made in place of it. If the paper is used, the level is marked on the paper with a pen after each quantity is added; if the diamond is employed, and this is best, a succession of slight transverse marks are made, commencing at the line running to the right. The length of these marks should be such as to distinguish the divisions; those indicating drachms being shorter than those for ounces.

In graduating by weight, the following data should be recollected. A cubic inch of mercury weighs 3425·35 grains, a cubic inch of distilled water at 62° Fahr., weighs 262·468 grains, and a fluid ounce (wine measure), of distilled water at 62° Fahr., weighs 455·6 grains.

If a measure is to be graduated by weight to cubic inches or fractions of a cubic inch, the operator prepares it with a strip of paper, or a diamond mark, as stated above, and for hundredths of a cubic inch he adds 34·25 grains of mercury, making a mark or scratch for each addition; and for tenths of a cubic inch 342·5 grains are added.

When the tube is not larger than one or two cubic inches, it may be poised on an accurate balance, and the additions of mercury made directly to it; but if the size is larger, it is safer and more convenient to weigh the mercury separately, and add it to the vessel to be graduated.

In tube graduation, Faraday recommends a block of wood to be placed over a piece of black paper against the wall, and nailed, so that part of the wood shall be on the black paper, and part on the white wall. The tube with the mercury in it is placed against the paper, and in the angle formed by the block and the wall, and the level of the mercury brought to correspond with that of the black edge of the paper. This greatly assists the eye. It is always necessary to allow for the curved edge of the mercury, at the point where it presses against the glass, the scratch being the slightest possible distance below the actual level, if a large tube, and rather further below if a small one.

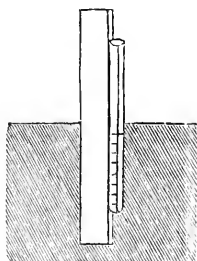
Alkalimeters may be graduated to hundredths of 1000 grains, sufficiently near the truth, if the tube is pretty accurate in calibre, by weighing ten consecutive quantities of one hundred grains each, and dividing the distances between the marks thus obtained with a pair of compasses.

When water is used, there is always a certain amount of adhesion to the sides of the measure above the level; time should therefore be allowed for this to collect below, as far as possible. Mercury sometimes encloses particles of air, but if a few minutes are allowed, this is forced to the surface, and the true level obtained.

The importance of having the surface of the fluid at right angles to the axis of the measure, during graduation, is self-evident, and hence in marking all vessels having a footstand, a perfectly level spot should be chosen to place them on at the time of marking.

After the degrees or divisions have all been scratched, the measures, if large, are best finished by the glass-cutter's wheel; but a good scratching diamond, or the sharp edge of a three-sided file, broken so as to form an acute solid angle, will enable the pharmacist to mark with sufficient neatness, all extraordinary vessels. It requires some dexterity to mark glass exactly in the spot desired, especially if a file be used; but this is soon acquired by practice.—W. P.]

Fig. 442.



THE CONNECTING AND LUTING OF APPARATUS.

When tubes are required to be connected, the union is usually and best effected by means of Indian-rubber connectors. These are made from a piece of sheet Indian-rubber, such as is now commonly met with in commerce. A slip of this substance being previously warmed,

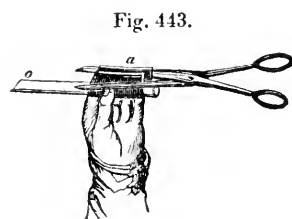


Fig. 443.

so as to render it perfectly pliant and elastic, is placed around the tube, as shown in fig. 443, and the ends are then cut off close to the tube with a pair of clean scissors. The scissors should be sharp, and previously warmed, and should be sufficiently long to admit of the ends of the Indian-rubber being removed by a single cut. [The scissors used by some pharmacutists expressly for cutting labels, are appropriate for this use.] The newly cut surfaces of the caoutchouc immediately adhere, wholly or in part, and the adhesion is perfected by pressing the surfaces together with the thumb nails. The connector is thus formed over the tube, from which it may be removed by passing some water between them so as to wet the surface of the glass. The connector may sometimes be made, as above described, over the ends of the two tubes which are intended to be connected, and it will then only require to be secured in its place, and the connexion rendered air-tight, by means of the binding-knot or pyrotechnical knot, applied over each tube.

Connecters of common Indian-rubber cannot be used for confining the vapours of essential oils and ethers, nor indeed any hot vapours. In these cases, the vulcanized Indian-rubber will be found to be much more serviceable. Tubes of various sizes and any length, made of vulcanized Indian-rubber, are sold by Messrs. Mackintosh, the patentees, and they may be economically and advantageously substituted, in all cases, for those made of common Indian-rubber.

Tubes are attached to the mouths of bottles, flasks, and other vessels, by means of perforated corks. Formerly the corks were perforated for this purpose with a red-hot iron, but this method was found

Fig. 444.



to be inconvenient, and was superseded by the use of the round file, such as fig. 444, the cork being first pierced by a thin file,

and the hole subsequently enlarged to the required extent by using files of larger size.

The most convenient, and in every respect the best method of perforating corks, consists in the use of the *cork-borers*, which I originally invented for that purpose. They consist of cylinders of tin-plate, about six inches in length, and varying in diameter to suit the different sized tubes. A wooden handle is fitted to one end of the cylinder, as shown in fig. 446, which greatly facilitates its use. There should be a set of these cylinders of such sizes that, without the handles, they may fit loosely one within another, the smallest being about a quarter of an inch in diameter. The cutting edge of the cylinder is sharpened with a small half-round file. It is found convenient to have a gauge (fig. 445), which has a series of notches corresponding with the diameters of the borers and marked with corresponding numbers, so that by fitting the tube to one of the notches, a suitable borer may be at once selected.

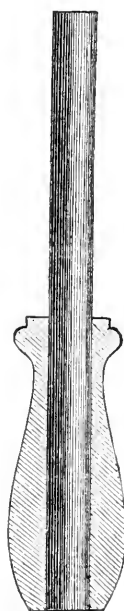
The method of using the cork-borers is very simple. A little oil being rubbed over the inner and outer surface of the cylinder, the cutting-edge is placed upon the cork in the proper place, and in the direction in which the tube is intended to pass. The cutting is effected by holding the cork in one hand and the borer in the other, while the latter is turned to and fro, and at the same time pressed against the cork until it has passed through. With a little practice corks may be cut in this way, so as to have a perfectly smooth cut surface. If none of the borers should be of exactly the right size for the tube, that one nearest in size, but smaller than the tube, must be used, and the hole subsequently enlarged with a round file.

In England cork-borers are usually made of brass. Fig. 447 represents a set of borers such as I am accustomed to use. The cylinder (*a*) is made of rather thin drawn brass tubing, to one end of which, at *c*, a short piece of a thicker tube is soldered, and through

Fig. 445.



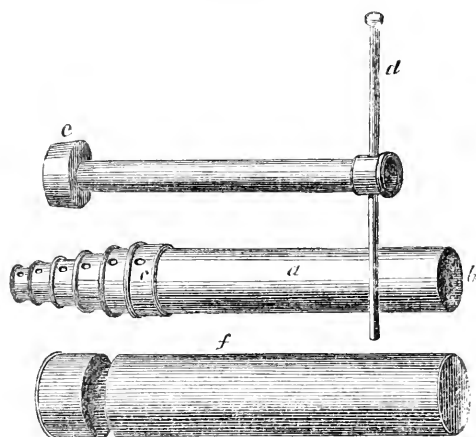
Fig. 446.



CORK-BORERS.

this there are two holes on opposite sides of the cylinder, for the reception of the iron rod (*d*).

Fig. 447.



CORK-BORERS.

The set consists of twelve borers of different sizes, six of which are shown in the drawing. These fit one within another, and are kept in the tin case (*f*), the rod (*d*) being put within the smallest cylinder. In the drawing they are represented as having been partly drawn out to show the succession of sizes, and the rod (*d*) is represented in the position in which it is placed in one of the borers when used in perforating a cork (*e*).

The corks by which connexions are made should never be left in the mouths of bottles, or other vessels, when the apparatus is not in use, as the long-continued compression to which they would thus be exposed would destroy their elasticity, so that after some time they would cease to fit tightly into the openings they originally stopped. After using the apparatus, therefore, the corks should be taken out or loosened, before putting them away for subsequent employment.

If the opening into which the cork is fitted be large, it will be difficult to get a cork that will, alone, form a perfectly air-tight connexion. The compression to which a large cork is submitted, when inserted in the mouth of a vessel, is not sufficient to close up the pores which always exist to a greater or less extent. In these cases it is necessary to use some kind of luting.

If no heat be employed in the process to which the apparatus is to be applied, a little grease will form a suitable luting. Lard, which has been mixed with about one-twentieth part of its weight of white wax, so as to give it a stiff and tenacious consistence, will be found a most useful luting for rendering cork connexions air-tight. It should be well rubbed into the pores and over the surface of the cork, and made to fill up every open space at the points of connexion between the cork and the glass. If, however, the apparatus is intended to be used for processes in which heat is applied, a different kind of luting will be necessary. A paste made of linseed-meal, or almond-meal,

and water, is the most common and generally useful luting. It may be applied, either alone, or with a piece of moist bladder tied over it, as represented in fig. 448. A mixture of chalk and linseed oil, also forms a good luting, which becomes very hard and impervious to vapours after it has stood for a day or two.

Fig. 448.



Fig. 449.

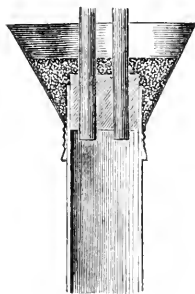


Fig. 450.



Fig. 451.



TUBE CONNEXIONS.

When there are two or more tubes inserted through the same cork, it is sometimes difficult to apply a stiff luting so as to form a neat and air-tight union. In such cases, plaster of Paris may be used advantageously in the following manner. A coil of paper is tied around the larger tube or mouth of the vessel, as shown in fig. 449, and the plaster of Paris, mixed with water to the consistence of cream, is then poured in so as to surround the inserted tubes. When the plaster has hardened, the paper is removed, and the luting scraped with a knife until reduced to a suitable form.

A solution of sealing-wax in spirit or naphtha is frequently applied as a kind of varnish to the surface of corks, when used for connecting apparatus. It constitutes the most elegant method of rendering the cork air-tight, but does not always supersede the necessity for the application of other luting to the points of contact between the cork and other parts of the apparatus. The solution of sealing-wax is, also, sometimes inapplicable, in consequence of its requiring some time to harden after it has been applied. There are some cases in which sealing-wax may be used advantageously without a solvent, the wax being ignited and allowed to drop, in the melted state, on to the cork, and surrounding parts of the apparatus, where it is spread as smoothly as possible by the still burning end of the stick, or by the subsequent

use of a hot iron. This method of luting will be found to resist the escape of very penetrating vapours, such as ammonia, which it is difficult to confine with other kinds of luting, and in the generation of which much heat is not applied.

For confining acid vapours, a mixture of pipe-clay and linseed oil, beaten into a tenacious paste in a mortar, should be used. Pipe-clay made into a paste with a concentrated solution of sulphate of soda is also sometimes used.

When much pressure has to be overcome, but no heat is applied, as for instance, in passing sulphuretted hydrogen through a solution into which the gas is conveyed to a considerable depth, I have found a stiff and tenacious clay to form the best luting.

The connexion of a small tube to one of larger diameter is sometimes effected by means of the neck of an Indian-rubber bottle, as shown in figs. 450 and 451.

Connexions of a more permanent kind than those above described, are usually made by the manufacturers of apparatus. The pharmaceutical operator will, however, frequently find it convenient to be able to repair or reconstruct a joint which has become defective.

Fig. 452 represents the union of a glass tube to one of brass, such as occurs in the water-index of the boiler, fig. 121, page 125. The glass tube is here inserted into the brass socket and secured with cement.

Fig. 452.

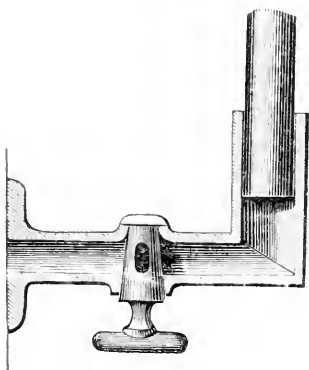


Fig. 453.

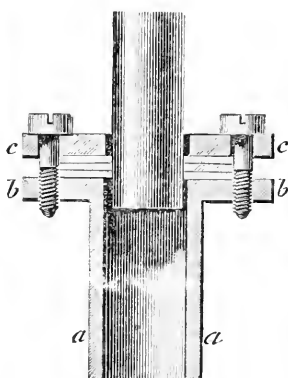
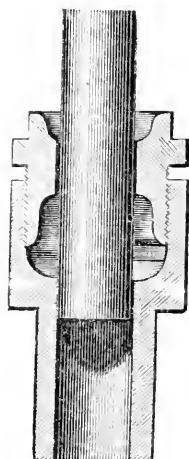


Fig. 454.



The best kind of cement to use in these cases is a mixture of ground white lead with a portion of red lead made into a tenacious paste with

a little boiled oil. This soon hardens, and then forms a perfectly tight joint, which is unaffected by high temperatures.

Fig. 453 represents another method of connecting a glass tube to one of metal. The metallic tube (*a*) has a broad flange, in which there are four screw-holes. Over this flange three circular disks of pasteboard are placed, each of which has a hole cut in its centre with a cork-borer, so as to fit tightly over the glass tube, whose end is inserted into the metallic tube. A disk of metal (*c c*) is then placed over the pasteboard and screwed down tightly. No cement is used in this case, and yet the union will be perfectly water-tight, even when applied to a steam-boiler, where some pressure is employed.

Figs. 454, 455, 456, and 457, represent other methods of connecting tubes. In fig. 454 the connexion is made air-tight by means of a stuffing-box. In fig. 455 two disks of pasteboard surround and closely embrace the glass tube, and these are secured in their place by an overlapping screw (*b c*), which screws on to the metallic tube

Fig. 455.

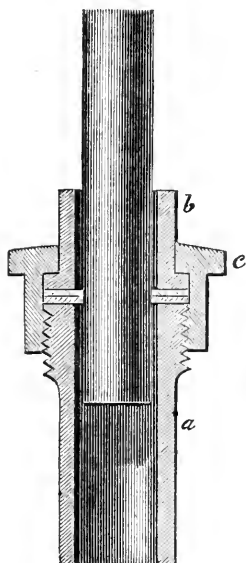


Fig. 456.

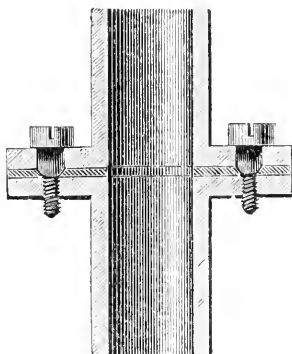
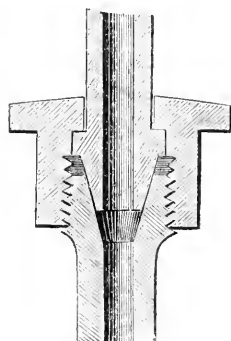


Fig. 457.



TUBE CONNEXIONS.

(a). Figs. 456 and 457 represent methods of connecting two metallic tubes.

COATING OF GLASS AND PORCELAIN VESSELS WITH COPPER.

At the exposition of works of art and manufacture in Paris, in the summer of 1844, there were exhibited glass and porcelain vessels of

different kinds coated with copper. The metallic coating was perfectly smooth and of uniform thickness, and the adhesion appeared to be perfect in every part. Among the vessels thus coated were flasks, retorts, receivers, evaporating dishes, &c. It was evident that the copper must have been deposited on these vessels by electricity, and that it rendered them much less liable to breakage, either from sudden changes of temperature or from other causes, than they otherwise would be.

After my return home, having brought some of the coated vessels as patterns, I made several experiments, with the view of ascertaining the best method of effecting this useful application of the electrotype process.

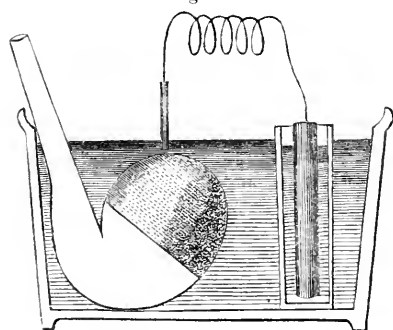
The first step in the process must of course be to cover the surface of the vessel with some substance capable of conducting electricity. In my early experiments I put a thin coating of copal varnish over the part on which the copper was intended to be deposited, and while this was yet adhesive it was covered with thin leaves of Dutch-metal. A conducting surface being formed in this way, and the varnish allowed to dry, the vessel was filled with water and immersed in a solution of sulphate of copper, such as is generally used for electrotyping, contained in a large earthen pan. In the same pan was placed a porous earthen vessel filled with diluted sulphuric acid, and containing a zinc cylinder, from which a copper wire was made to communicate with the conducting surface of the vessel to be coated. The part of the wire that passed through the solution of copper was isolated by enclosing it with sealing-wax in a glass tube. With this simple arrangement

a sufficient deposit of copper was obtained in three or four days, care being taken from day to day to turn the vessel under operation so as to present a new surface towards the zinc cylinder, as the copper is always deposited more rapidly on the parts facing the zinc than on any others. Fig. 458 represents the whole arrangement.

In subsequent experiments, I found that metallic bronze powder

brushed over a thin coating of varnish forms the best conducting surface on which to deposit the copper.

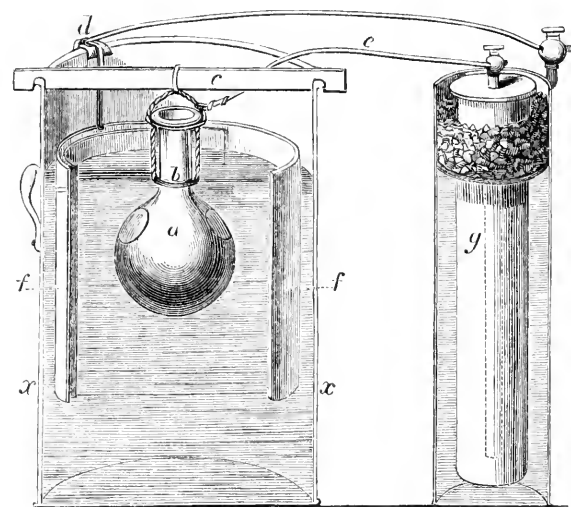
Fig. 458.



COATING OF VESSELS WITH COPPER.

My experience in the use and preparation of vessels coated with copper dates from the same period as that of Dr. Mohr. I brought several coated glass vessels from Paris in 1844, some of which have been in use ever since. I have not, however, found that so simple an arrangement as that described by Dr. Mohr, for depositing copper, afforded satisfactory results. The arrangement which I have found to answer best is that represented in fig. 459. A thin coating of fat varnish (not spirit varnish) is, in the first place, applied with a camel's-hair brush, over the part of the vessel on which the metal is intended to be deposited, leaving two or three uncovered circular spaces, as shown on the flask (*a*) in the drawing. When the varnish has become nearly dry, but is still sticky, some bronze powder is brushed over it with a thick camel's-hair brush. A perfectly bright and uniform metallic surface is thus produced over the varnished part.

Fig. 459.



COATING OF VESSELS WITH COPPER.

A copper wire is, in the next place, twisted around the neck of the flask at the point (*b*) at which the bronzed surface commences, and in contact with it. This copper wire is carried up on each side of the neck of the flask, and again secured immediately below the projecting rim or lip, from whence it is formed into a loop over the mouth of the vessel. The flask, thus prepared, is filled with water, and a suffi-

cient quantity of shots put into it to make it sink in the solution of copper. The solution consists of two parts of a saturated solution of sulphate of copper, and one part of a saturated solution of sulphate of soda, to which as much sulphate of copper as it is capable of dissolving has been subsequently added. This solution is put into a large copper vessel (*x x*), across the top of which is placed a bar of wood (*c*), from which the flask is suspended. A sheet of copper, coiled into a circular form (*f f*), is also immersed in the solution, so as to surround the flask, and a copper wire (*d*) connects this with the positive pole of a constant battery, while the flask is at the same time connected with the negative pole by the wire (*e*). The battery (*g*) is a large Daniel's battery of the usual kind. With this arrangement the copper will be deposited of sufficient thickness in about two days.

There are several advantages in the use of glass vessels thus coated with copper. They are rendered less liable to be broken than they otherwise would be. When exposed to the flame of a lamp, the heat is more equally distributed over the surface of the vessel; and condensation is prevented in the upper part of the globe when used for distillation. I have not found any indications of a separation of the metal from the glass, even after long use. I am informed, however, that they do not answer for the distillation of liquids which boil at a very high temperature. On applying them for the distillation of oil of vitriol, it has been found that the copper speedily becomes oxidized, and the coating thus destroyed.

PREPARATION OF WAXED-PAPER.

Tissue-paper is most advantageously employed for making waxed-paper. It absorbs but little wax, and when prepared has an elegant appearance, and is easily moulded to the mouth of the gallipot or other vessel to which it may be applied. In accordance with its name, waxed-paper should be prepared with wax, but practically it is frequently made by impregnating the paper with stearine, and sometimes with oil. Stearine appears to answer nearly as well as wax.

Waxed-paper is prepared in the following way. A plate of iron, the upper surface of which is quite clean, is placed over a furnace until it has become warm. On the iron plate a sheet of stout paper is laid, and over this the tissue-paper. A piece of wax or stearine is

now placed in the centre of the paper, and as it melts it is spread out in all directions with a suitable instrument, while the paper is, at the same time, moved so as to bring the different parts alternately over the centre or hottest part of the furnace. The complete and equal distribution of the wax over the whole of the paper requires the exertion of some force. The rubber or instrument by which the wax is spread, should be so constructed that while it presents a soft surface, it shall not be too absorbent. I am accustomed to make the rubber by first rolling a slip of paper into a cylinder, covering this with tin-foil, and finally surrounding the tin-foil with a double layer of linen. The tin-foil prevents the absorption of the wax by the paper.

An iron plate answers better than one of any other metal for supporting the paper, especially when stearine or stearic acid is used. Copper or brass would be acted upon by the fatty acid, and a colour would thus be imparted to the paper.

Waxed-paper may also be prepared by holding a sheet of paper by the four corners in front of an open fire until it becomes hot enough to melt a piece of wax when rubbed over it. In doing it thus, the operator requires assistance. It may be done with one assistant, who holds the two corners of one end of the sheet of paper, while the operator himself holds the paper with his left hand midway between the two opposite corners, and then, holding in the other hand a cake of white wax which has been cut across its centre, so as to present the straight edge to the surface of the paper, this is rubbed quickly over every part until a thin film of wax has been uniformly imparted.

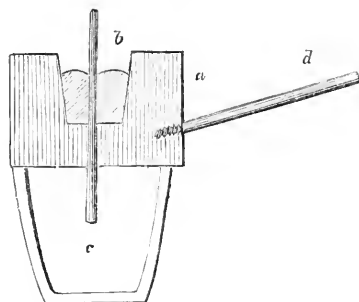
THE CASTING OF ZINC, POTASH, AND LUNAR CAUSTIC.

Zinc is sometimes cast in cylinders for using in Döbereiner's lamps. The clippings of sheet zinc, which may be purchased at the zinc workers', are economically used for this purpose. The mould for casting the zinc is sometimes made of thin pasteboard, or even of thick paper, rolled up so as to form a hollow cylinder of the required size, and then bound on the outside with string. This cylinder is placed upright in a vessel of sand, and a round stick is fixed in the centre of it, the lower end of the stick being inserted into the sand. The zinc should be melted with the least possible amount of heat, and poured into the mould. If the metal be made too hot it will burn the paper.

I have adopted a much more convenient, and generally better method than the above for casting these cylinders. Fig. 460 (*a*) re-

presents the mould, which is made of cast iron. It is of a cylindrical form, three or four inches in diameter, and of the required depth. There is a round hole (*b*) in the centre, of the size of the intended cylinder. The diameter of this hole is rather less at the bottom than at the top. There is also a small hole passing from the centre of the latter through the bottom of the mould, and through this an iron rod (*c*), which slightly tapers towards the top, is passed from below upwards, and temporarily fixed, as shown in the drawing, by striking it with a hammer. A handle (*d*) is attached to the side of the mould.

Fig. 460.



MOULD FOR CASTING ZINC CYLINDERS.

The rod (*c*) being fixed in its place, the mould is placed over the mouth of an empty crucible, or on any other suitable stand, and the melted zinc is poured into it at *b*. As soon as it has become solid, and sufficiently cooled, the rod is knocked out, and the mould being then turned over with the bottom upwards, and struck gently with a hammer, the zinc cylinder falls out. The rod is now again put into its place, and another casting made. Thirty or forty cylinders may be thus cast in a few hours.

The rod (*c*) being fixed in its place, the mould is placed over the mouth of an empty crucible, or on any other suitable stand, and the melted zinc is poured into it at *b*. As soon as it has become solid, and sufficiently cooled, the rod is knocked out, and the mould being then turned over with the bottom upwards, and struck gently with a hammer, the zinc cylinder falls out. The rod is now again put into its place, and another casting made. Thirty or forty cylinders may be thus cast in a few hours.

Hydrate of potassa and lunar caustic are cast into small cylindrical sticks, and are used in this form by surgeons.

Fig. 461.

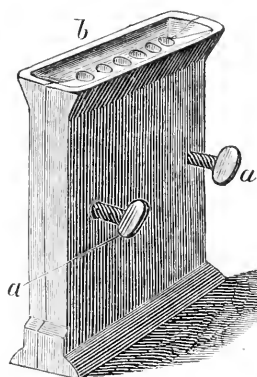
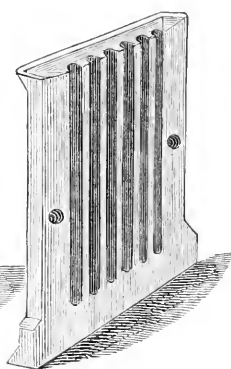


Fig. 462.



MOULD FOR CASTING HYDRATE OF POTASSA, AND LUNAR CAUSTIC.

Fig. 461 represents the kind of mould used for casting them. The mould is made either of iron or of brass. Iron should always be used for casting potash; but the moulds for casting lunar caustic are generally made of brass or gun-metal. The mould consists of two metallic plates, (*b*), fig.

461, which are grooved, as represented in fig. 462. These plates are

joined together by the screws (*a a*), and the substance to be cast is poured, in the melted state, in the cavity at the top, and allowed to run into the grooves. When it has hardened, the mould is unscrewed, the two plates taken asunder, and the cylinders removed from the grooves.

[It is sometimes desirable to point a stick of lunar caustic for surgical purposes, and it is troublesome to effect it with a knife. The most easy and elegant mode of doing it is to hold a large silver coin with a pair of forceps over a spirit lamp, until hot enough to fuse nitrate of silver. The stick of caustic to be pointed is covered at one end to protect the fingers, and held at an inclination of thirty degrees to the hot surface of the coin, pressed against it, and as the side of the stick fuses off, it is turned until a uniform and smooth conical point is produced. Of course the point will be sharp in proportion to the inclination of the stick. Sticks of caustic potash may be sharpened in the same manner.—W. P.]

CLOSED OPERATING CHAMBER OR CLOSET.

There are so many operations in the laboratory in which noxious vapours are evolved, that it is always desirable, if it can be so arranged, to have a chamber or closet communicating with the chimney, and having a glazed door in front, by which the escape of vapours into the apartment may be prevented. A closet of this description is represented in fig. 463. It should be fixed against a chimney, into which all vapours evolved in it may be conducted through an opening provided for the purpose near the top of the closet. It should also be so situated that sufficient light may enter through the glazed door in front. The closet from which the drawing, fig. 463, has been made, is constructed in the following manner.

Two thin brick walls (*a a*) are run up to form the sides of the closet. These are about three feet and a half distant from each other, and they project about twenty-seven inches from the wall of the room. The operating table (*b*) is fixed at a height of thirty-two inches from the ground, and consists of a cast-iron plate resting on a stone slab. The iron plate is made to slide in a groove on each side, so that it may be easily removed and replaced at any time, without otherwise disturbing the closet. The height of the table is so arranged that a dish or other vessel, placed on a small furnace within the closet, shall be in such a position as to admit of the contents being closely observed by the operator.

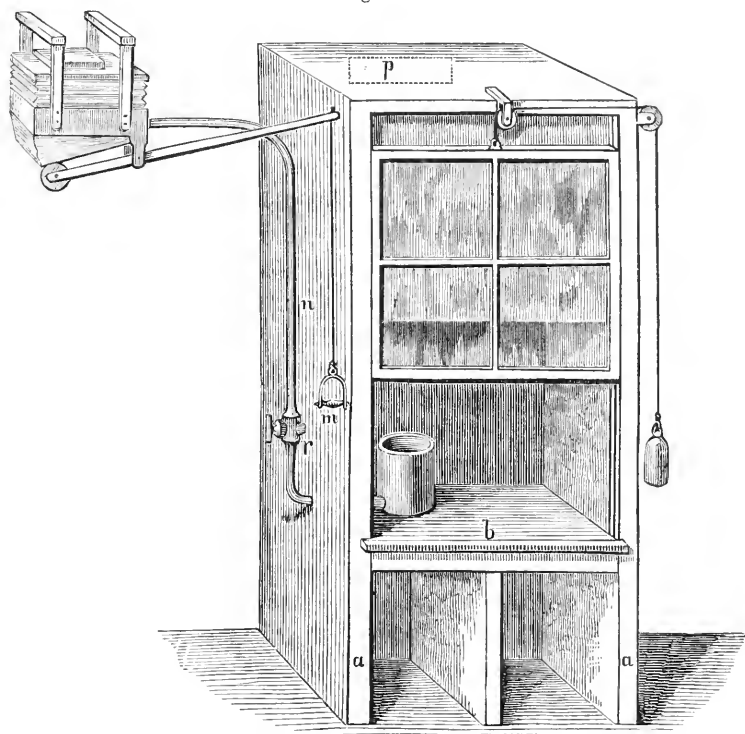
The space between the operating table (*b*) and the ceiling is enclosed,

partly by a brick wall, and partly by a glass door. The upper half is bricked in the same way as the sides of the closet, the brickwork being supported on a strong iron bar. The lower half is enclosed with a glazed sash, running in a frame like a common window-sash, and counterbalanced by a weight.

The space below the operating table is divided into two compartments by a wall. Fuel is kept in one of these compartments, and apparatus in the other.

A double-acting bellows is fixed near the ceiling, and the rope and stirrup (*m*) by which this is worked hangs on the left hand side of the closet. The pipe (*n*) of the bellows enters the closet through the wall at such a height above the operating table that it may enter the air-pipe of one of the furnaces, figs. 66, 67, or 68.

Fig. 463.



CLOSED OPERATING CHAMBER OR CLOSET.

The obvious advantages resulting from the use of this closet, in a variety of operations in which noxious vapours are evolved, will amply compensate for the expense of its erection.

CHAPTER XVI.

GENERALITIES. INFUSIONS AND DECOCTIONS. READING THE PRESCRIPTION. MIXTURES, DRAUGHTS, DROPS, EMULSIONS, POWDERS, ELECTUARIES, CONSERVES, AND LOZENGES.

EXTEMPORANEOUS PHARMACY.

THE extemporaneous admixture and preparation of medicines from the prescriptions of medical men, and the supply or administration of remedial agents to the public, constitute the primary objects, and most ostensible duties of the pharmacist. All other operations are performed in anticipation of those connected with the dispensing of medicines.

The duties of the dispenser are of a very important nature, and for their due discharge a certain combination of qualities is required in the individual who undertakes them. With some degree of physical strength and agility, he should combine a quick perception, sound judgment, and firmness of resolution. He should maintain a constant and lively attention to every operation, however trifling, with which he may be occupied, and evince, both by night and by day, a readiness to fulfil his duty in serving others, even at the sacrifice of his own convenience and pleasure.

The art of dispensing is generally learnt from practical demonstration, and this, indeed, is the only method of acquiring expertness in the various manipulations which the art involves. It is not, therefore, contemplated in the observations which will be offered here, to supersede the necessity for practical instruction, but merely to give the results of many years' observation, with the view of supplying some facts to the less experienced, and of inducing a habit of observation and reflection with reference to the most apparently simple phenomena.

The operations of dispensing are carried on at the counter appropriated to that purpose, either in front and within view of the cus-

tomers, or behind a screen which intercepts the view. The construction of the dispensing counter, without the screen, has been described elsewhere. The screen, which usually consists of a curtain, or of a wooden erection, on the front edge of the counter, and extending to about the height of a man's shoulder, or not quite so high, is generally adopted in the north of Germany. There is much difference of opinion with regard to the supposed advantage of this arrangement. As much, probably, might be said against it as in its favour. To the dispenser, it may be more agreeable to carry on his operations behind the screen, where he is not exposed to the scrutinizing eye of the patients, who might otherwise be watching his fruitless attempts at effecting the combination of some rebellious constituents of a pill-mass, or criticising the accuracy with which he divides out a powder into the separate doses. But, on the other hand, an accomplished dispenser should be capable of evincing his skill by adroitly overcoming difficulties; and the stimulus which the observation of the customer affords to the cultivation of habitual expertness and careful attention, is one of the advantages of the unscreened counter.

The existence of the screen will naturally excite in the mind of the customer a suspicion that something is being done with which the operator is anxious that he should not become acquainted; and it is also calculated to induce carelessness on the part of the operator, which would probably become habitual. Under such circumstances, the dispenser may be sometimes seen in his dressing-gown and slippers,—a habit which cannot be too strongly condemned. He should every morning make his appearance, from the commencement of the hours of business, neatly, but not expensively dressed. Before his customers, and indeed at all times, while engaged in the operations of dispensing, he should be careful to observe the greatest possible cleanliness, and to avoid everything that would be calculated to excite feelings of disgust.

The dispenser who licks the lip of the syrup-bottle, after pouring out what he requires; who removes any foreign body from a mixture by putting his finger into it, or puts a cork between his teeth to soften it and make it fit the mouth of a bottle, might be compared to an ill-bred person, who, at meal-time, drinks from the decanter, helps himself to salt with his fingers, or cuts bread from the loaf with a knife which has just been in his mouth. He who prepares the dose for the sickly, and often fastidious patient, should be especially careful that he add no extraneous repulsiveness to that which, of necessity, belongs to the prescribed remedy.

MEANS FOR PRESERVING CLEANLINESS.

The means by which cleanliness is preserved, should be amply provided in the dispensary. The most important of these means is water. *A sink with water laid on*, in a convenient situation, for the use of those engaged in dispensing, is indispensable. If there should not be a water-cistern on the premises, from which a supply might be conveyed to the sink by a pipe, it will be necessary to provide a vessel for this purpose. It is desirable that the cistern should not be at a great height above the stop-cock at which the water is drawn, as the force of the current would in that case be so great as to cause much splashing of the water in using it for washing a measure-glass or other vessel. The size of the tap should also be such that it may pass into the mouth of a bottle.

[The supply of water should be plentiful to meet all the demands of cleanliness. The *sink* should be, when admissible, 20 by 25 inches, the narrow side front, and 8 inches deep. The rear should be shelved over, the lower shelf being a drain for washed mortars, vials, &c. The conveniences for removing labels, old corks, and deposits in bottles, should be at hand, and bottles containing solution of potash in water, and solution of soap in alcohol, and muriatic acid, should be placed within reach. Several quills, wire loops, and hooks, rods armed with sponges, in fact every article that facilitates the process of cleansing, should be kept near the sink. The bottom of the sink should be about ten inches below the level of the counter, and a valve should be provided to close the orifice of the waste-pipe, both to allow of the sink being filled with water, for the purpose of cooling bottles of syrup, plaster, &c., and also to prevent the constant dripping in the winter season, which soon causes the stoppage of the pipe at its exit in the street by the ice formed.—W. P.]

A good sponge is another requisite. It should have a string attached to it, by which it is hung from a nail in some suitable place. The sponge is used for wiping up any water, or substances soluble in water, that might be spilled on the counter. It is kept in a moist state, so that it will readily absorb any liquid, and it should always be washed and squeezed before being returned to its place after use. Care should be taken, however, that the sponge is never used for wiping any kind of grease, as this would render it subsequently useless, until it be well cleaned with soap or carbonate of soda and hot water.

Two towels, or cloths, will also be required, which should be of different degrees of fineness. These may be kept in a drawer, but must be ready of access. Many dispensers appear to be ignorant of the proper use of the towel. The finer towel ought to be used only for wiping clean water off the bottles, measures, or other objects which have been wetted, or which require delicate cleaning. The coarser towel may be employed to remove the dust from the counter, or for other similar purposes. But it should be borne in mind that whatever dirt is removed from an object with the towel, may become attached to the next object to which the towel is applied. The practice so commonly adopted, of wiping up all kinds of dirt with the towel, seems to indicate a great want of discernment or reflection in the operator, for such conduct, after two or three repetitions of it, only increases his difficulties by rendering the towel of no further use. Powders, or anything more than a sprinkling of dust, should be always removed with a dusting-brush, or the coarse towel should be used in such a way as to remove the dust from the object without holding it in its texture. Syrups, mixtures, extracts, and all substances of this kind, which are soluble in water, should be removed with the wet sponge, and the place then wiped dry with the towel. All greasy substances should be carefully removed with blotting-paper, saw-dust, or a piece of tow. A little attention to these points will save a great deal of inconvenience and trouble, and will greatly facilitate the maintenance of cleanliness.

AIDS TO DISPENSING.

There are several preparations which may be made for the purpose of aiding or expediting the operations of dispensing. As by adopting such means the properties of the medicines are not altered, while the pharmacist is enabled with greater facility to dispense them, no possible objection can be urged against the practice. Indeed, in some cases, there is decided advantage, independently of the saving of time, in having the requirements of prescriptions met by anticipation, and operations which are ordered extemporaneously, performed during leisure hours, when greater attention can be devoted to them.

Thus, for instance, many salts which are frequently ordered in prescriptions, are advantageously kept in fine powder, in which state they will more readily dissolve in any fluid. In this way the use of a mortar, which otherwise would be required, may be dispensed with, in

effecting solution. It is important, however, that due care should be taken to ascertain that the salt, when powdered, has the same composition as the crystals, or, at least, that there is some known and definite relation between them. Efflorescent salts, such as carbonate of soda and sulphate of soda, would lose a portion of their water of crystallization in being powdered, unless the process were conducted with special precaution. Sesquicarbonate of ammonia would also be likely to undergo some change. These salts, even if ascertained to be unaltered in composition when first reduced to powder, would be more likely to undergo change from exposure to the air in this state than they would if the crystals were unbroken. Moreover, it would be more difficult to detect the occurrence of change by the eye, in the case of the powder, than it would be in that of the properly crystallized salt. But there are many salts, such as sal ammoniac, nitrate of potash, alum, and sulphate of magnesia, which are not subject to the changes indicated from mere exposure to the air. It would be necessary, of course, carefully to distinguish between salts powdered with their water of crystallization, and those, such as alum and sulphate of magnesia, which are sometimes rendered anhydrous before being powdered.

Again, there are some salts which may be very conveniently kept in solution for use in dispensing. Of this class are sulphate of magnesia, sal ammoniac, and carbonate of potash. It is desirable, unless there be some obvious reason for doing otherwise, to make such solutions of uniform strength; and the strength should be such as to admit of easy calculation in determining the quantity of solution that shall contain a specified quantity of the salt. As the solution would be always apportioned by measurement (in England), while the salt is ordered by weight, the weight of the latter should bear a simple relation to the volume of the former. The most convenient proportions will be those in which f3iv of the solution shall contain 3i of the salt. A solution of this kind is made by dissolving 3v troy weight of the salt in water, and making the solution to measure f3xx. Solutions thus made, of the salts above named, will be of such strength that there will be no chance of any portion of the salt being deposited in cold weather, while, at the same time, calculations will be easily made. The labels of the bottles should indicate the strength of the solutions.

There are some salts which are not unfrequently ordered in prescriptions, but which, nevertheless, cannot be kept in solution in consequence of their undergoing decomposition. Emetic tartar (potassio-

tartrate of antimony) is a salt of this kind, and indeed most salts which contain organic acids belong to the same class.

[Citrate of iron is an exception to this rule, and though really a very soluble salt, it dissolves with great slowness, and frequently causes delay and trouble in prescriptions. If four ounces of this salt be added to twelve fluid ounces of boiling water in a capsule, and the mixture heated till dissolved, and until it evaporates to eight fluid ounces, the solution will remain perfect when cold, and each fluid drachm will contain half a drachm of the salt.—W. P.]

Salts, the solubility of which varies much with differences of temperature, cannot often be conveniently kept in solution, unless much diluted, as the strength of the solution would be liable to variation from the deposition of crystals in cold weather. This is the case with sulphate of soda and nitrate of potash, which, although very soluble at temperatures above 60° or 70°, are very much less soluble at low temperatures.

There are other substances which may be kept in solution, such as manna, extract of liquorice, and gum ammoniacum. The pharmacist will, of course, be guided in his selection of those which it will be most desirable to keep thus prepared, by the common requirements of the locality in which he is situated. The practice of a neighbouring physician may render a preparation useful in a particular place, while there would be no demand for it in a different locality.

In some places, *Griffiths's Mixture* (the *Mistura Ferri composita* of the Pharmacopœia), is very frequently ordered in prescriptions, and as some time is occupied in properly preparing this mixture, it may, in such case, be kept partly prepared beforehand, by which means the operation of dispensing it will be greatly expedited. The emulsion of myrrh, carefully made from picked pieces of the gum-resin, which, when broken, present an opaque and milky appearance in the centre, and to which all the ingredients, excepting the sulphate of iron, have been added, may be kept in a stoppered bottle for several weeks without undergoing any change, and the mixture will be at any time completed by adding to a portion of it the proper quantity of sulphate of iron.

Aromatic confection is sometimes kept mixed with water, so that f3ij of it shall contain 3j of the confection. This mixture requires to be shaken up in the bottle in which it is kept, so that the ingredients may be held in suspension when a portion of it is poured out. It should not be long kept thus mixed, as it is liable to undergo fermentative decomposition, especially in warm weather.

Some *extracts* and *pill-masses* may be conveniently kept for use in dispensing, in a state different from that in which they are ordered in the Pharmacopœia. Thus, it is often found advantageous to have *compound extract of colocynth* in the form of powder, as well as in the soft state. *Extract of jalap* is also kept in powder. The pharmacist should always prepare these powders himself. The greatest possible care and attention are required to avoid injuring the qualities of the extracts in the desiccation to which they are submitted. An accurate determination must also be made of the relation in weight which the powder bears to the extract in its original state, and this relation should be specified on the label of the bottle in which it is kept.

Plummer's pill (*Pilule hydrargyri chloridi compositæ* of the Pharmacopœia), is frequently kept in powder, one of the ingredients, namely, the treacle, being omitted; by which means the strength is increased one-fifth. The object in adopting this method of keeping the pill, is to obviate the inconvenience often experienced, when it is kept for some time in the form of pill-mass, made with treacle, from its becoming hard and intractable. In using the powder the difference in strength must be taken into account, and the treacle or other excipient added.

The concentrated infusions constitute important, perhaps the most important, aids to dispensing. These preparations have come into very general use, and in many establishments they are always substituted for the infusions made according to the instructions of the College. It is very questionable whether the practice of using concentrated infusions in dispensing medicines can be justified, excepting under particular circumstances. Some concentrated infusions, which I have met with in commerce, certainly afford, when diluted, very near approximations in all their sensible qualities, to the infusions made in the ordinary way, but others have been found to be of a very different character, and to be greatly deficient in strength, or in the properties peculiar to the infusions they represent. In all cases, where circumstances will admit, I think the use of concentrated infusions ought to be avoided, at least until they are sanctioned by the College. Every pharmacist should, however, be provided with the means of supplying the best substitute for a properly and recently made infusion in a case of emergency.

When the dispensing-counter has a boarded screen in front of the dispenser, a very useful aid to his operations may be afforded by having a set of small bottles, containing those substances which are most frequently ordered in prescriptions, arranged on shelves against the screen.

[Whether there be a screen or not, a shallow upright glass case should be adjacent to the dispensing counter, capable of containing one hundred or one hundred and fifty glass-stoppered vials, of capacity from two ounces to half an ounce, arranged in steps, and distinctly and appropriately labelled. These bottles should contain the organic alkalies and their salts, neutral organic principles, as salicin, piperin, santonin, &c., powerful vegetable products, as elaterium, lactucarium, virgin scammony, &c., and a long list of vegetable powders used in prescriptions occasionally, and which should be kept only in small quantity, those of leaves being protected from the light. There are many substances which are largely sold at the counter, and require to be kept in large bottles, that may with advantage be kept in this case, as for instance, powdered aloes, ginger, carbonate of soda, alum, borax, and many others. Not only is time saved by thus having a great number of medicines within a small compass, but the bottles occupy so little room on the counter that they do not interfere with the convenience of the dispenser, whose last duty before returning them to the case should be to observe that they are the ones proper for the prescription, just compounded.—W. P.]

INFUSIONS AND DECOCTIONS.

The preparation of infusions and decoctions is a very troublesome, yet necessary part of the operations connected with the dispensing department. Much difficulty and inconvenience are frequently experienced, especially in houses where there is not much dispensing, in providing a supply of these preparations, at the times and in the quantities suited to the daily requirements of the business. In consequence of their proneness to undergo change, they cannot be kept, under ordinary conditions, for more than a day or two, especially in warm weather. They ought, therefore, to be made on the day on which they are used in dispensing, otherwise they may be sent out in a state of incipient decomposition. If they be not prepared in anticipation of the requirements of the day, much inconvenient delay will often be occasioned in supplying medicines that are ordered; and if they are prepared every morning in readiness, there will often be much waste in consequence of the uncertainty of the demand.

It is not customary to keep decoctions ready made, excepting, occasionally, decoction of bark, or any particular one which local or temporary circumstances may call into unusual requisition. It is also

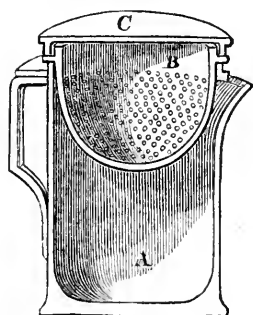
very rarely found necessary to keep the whole of the infusions in readiness, but their use is much more general than that of the decoctions, and some of them, such as the infusions of senna and roses, are in daily use in most localities.

The nature and extent of the business will indicate the amount of daily preparation required in reference to the supply of infusions and decoctions; and in accordance with this, means for preparing them must be provided.

The pharmaceutical stove, described at page 125, if kept in daily operation, will afford efficient accommodation, as far as regards the supply of boiling water and of heat.

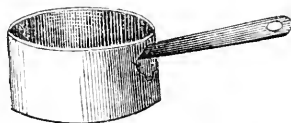
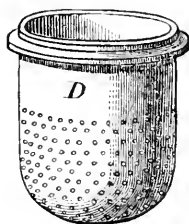
The infusion-pot, fig. 464, which has been described at page 245, is the vessel best suited for making infusions in; and a flat-bottomed saucepan, such as fig. 465, may be conveniently used for boiling decoctions. A saucepan of this kind may be placed on the hot plate of the pharmaceutical stove, where two or three of them may be kept boiling at the same time.

Fig. 464.



INFUSION-POT.

Fig. 465.



DECOCTION SAUCEPAN.

Those infusions which are intended to be kept ready, should be prepared the first thing every morning. The infusion-pot (fig. 464) serves for making the infusion in, for straining it when made, and subsequently for keeping the strained liquid in. There should be a separate pot for each infusion, and there is a flat projection immediately over the handle which is intended to bear the name. The ingredients are put into the perforated dish (*b*)—if they are very bulky a deeper dish, such as *d*, is employed—and the requisite quantity of water is poured over them. When they have stood for the specified time, the perforated dish containing the solid ingredients is removed, and the clear liquor which remains will then be ready for use. The

great facility with which the infusion is thus strained, without even the necessity for a second vessel to put the strained liquor into, constitutes one of the strongest recommendations to the adoption of this infusion-pot. It is not an unfrequent practice to leave infusions in the vessels in which they are made, in contact with the solid ingredients, for a much longer time than that specified in the Pharmacopœia. Sometimes the infusion is strained from the vessel in which it is made, from time to time, when wanted, by which means a continued cold maceration is maintained until the whole has been used, or a fresh set of ingredients is put under operation. This practice is very objectionable, as the infusions, especially some of them, assume a very altered character from prolonged contact with the solid ingredients.

[An infusion-pot on the principle of Mr. Squire's may be made of tin in such a manner that the diaphragm shall be movable. The latter should consist of a cylinder of tinned iron one-third of the height of the mug, the strainer being made of finely perforated tin, such as is employed for coffee displacers. If the pot holds a pint, by means of a small wooden plug the diaphragm may be fixed at any height, so that half a pint or four fluid ounces of an infusion may be made equally well. Such an infusion-pot, however, would not be appropriate for the infusion of substances containing tannin.—W. P.]

The gas-furnace (fig. 466), with the burner (fig. 467), may be some-

times more conveniently used than the stove, for making decoctions. This method of operating possesses many advantages, and no other means need be provided wherever there is a constant supply of gas during the day as well as night. It is economical, inasmuch as it obviates the necessity for keeping a fire throughout the day, which might not otherwise be required; and the gas can be lighted in a moment when wanted, and extinguished

Fig. 466.

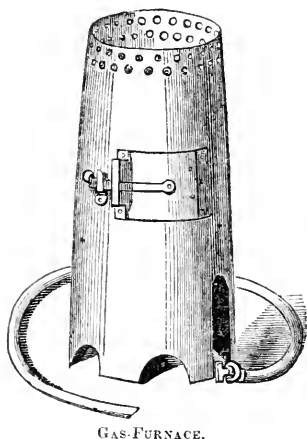


Fig. 467.



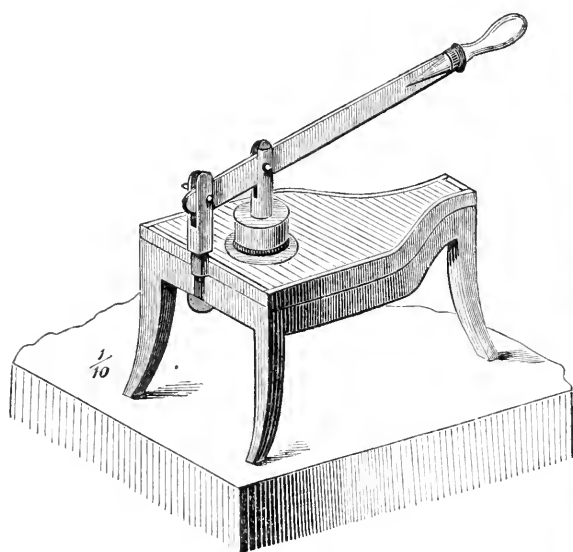
GAS-BURNER.

when done with. Even if a stove be employed as the common daily source of heat for these operations, it will be desirable to have a gas-

furnace which can be used at night, if there should happen to be occasion for it.

Dr. Möhr describes an apparatus for straining decoctions, which is called *Beindorf's decoction press*. It is represented, entire, in fig. 468, and parts of it in figs. 469, 470, and 471. The object in using this press is to facilitate the straining and pressing of a hot decoction. Fig. 471 is an iron or tinned copper funnel, which is inserted in the

Fig. 468.



BEINDORF'S DECOCTION PRESS.

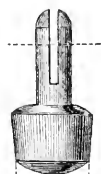


Fig. 469.

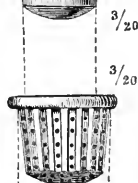


Fig. 470.

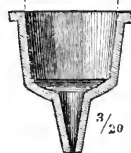


Fig. 471.

wooden frame of the press, the tube projecting through the bottom; fig. 470 is a perforated cylinder which fits within the funnel; and fig. 469 is a wooden block that fits into the cylinder. The lever of the press is attached by a hinge to an upright bar forming the fulcrum, which turns in a socket, so that when the block (fig. 469) is fixed to the lever, as shown in fig. 468, this may be turned from the mouth of the funnel to admit of the introduction or removal of the ingredients to be pressed, and again brought over the cylinder when pressure is required. A straining-cloth is first put into the cylinder, and a vessel placed beneath the frame to receive the strained liquor; the decoction is then poured in, and pressure applied by means of the lever and attached block.

The foregoing arrangements for the preparation of infusions and

decoctions would fully meet the requirements of a good dispensing business, and with such provisions the only difficulty and inconvenience likely to be felt would be those contingent upon the uncertainty of the demand for the preparations in question, and the constant attention required in maintaining an adequate supply of them. Much more difficulty, however, is experienced by those who have very little dispensing business. In these cases the demand for infusions is often insufficient to induce the daily preparation of any one of them in anticipation of their being required; yet they are occasionally called for; and if a customer, who has previously had his medicine dispensed elsewhere, without delay, is told that the preparation of it will occupy several hours, he sometimes becomes mistrustful of the dispenser, or impatient of the delay. This is a frequent source of annoyance to the pharmacist, and has been one reason for the adoption, so generally, of the concentrated infusions in place of those made according to the Pharmacopœia.

Mr. Alsop has suggested a good method of preserving infusions, which might be very advantageously adopted by those who have not a sufficient demand for them to make it worth while to prepare them daily. The infusion is introduced into bottles provided with well-ground stoppers, and which are filled to the brim. If the infusion was not hot when put into the bottles, it must be subsequently made so by plunging the bottles into boiling water, and leaving them there for some minutes. The stoppers, which should be of rather a conical form, tapering downwards, and smeared with a little wax, so that they may fit perfectly air-tight, and not become immovably fixed in the mouths of the bottles, are now to be inserted. In doing this each stopper will displace a portion of the liquid from the mouth of the bottle, thus insuring the total absence of air. As the liquid cools, it will contract, and leave a vacuum in the upper part of the bottle. If the operation be carefully conducted, so as completely to exclude the air, the infusion will keep for weeks, or even for months, without undergoing any change. Mr. Alsop states that he has kept infusion of *cusparia* in this way for nine months, including the summer months, and at the end of that time it was in every respect as good as when first made. He suggests that the stopper of each bottle used for this purpose should be tied to the neck of the bottle, to prevent its being misplaced.

[The preparation of infusions and decoctions in this country is very generally confided to the nurse, or some member of the family of the patient, the ingredient or ingredients being directed to be boiled, or

infused, in a certain measure of water. This course, adopted on economical grounds, is often the cause of physicians being imperfectly served, especially where they do not direct the substances to be confused. In the majority of such cases, the dispenser should assume the responsibility of reducing the drugs to a proper state of division.—W. P.]

READING THE PRESCRIPTION.

When a prescription is presented for preparation, the first thing to be done is, to read and to understand it. This is sometimes the most difficult part of the dispenser's duty. It requires the exercise of serious attention, quick perception, sound judgment, and prompt decision. The writing in prescriptions is often very bad, and the words are mostly abbreviated; moreover, the language in which prescriptions are written is, in the majority of cases, very imperfectly known to both the writer and the reader. There are, it is true, but a limited number of formal expressions which are commonly used for conveying the requisite instructions, and a knowledge of these is easily acquired; but the pharmacist will not be qualified for his duties as a dispenser, if he possesses only a knowledge by rote of the expressions most frequently used in prescriptions. The prescription is intended as a medium of communication between the prescriber and the dispenser, and an acquaintance with the language in which it is written is quite as requisite to the latter as to the former.

The dispenser has a twofold difficulty to contend with; he must first decipher, and then translate the writing of the prescription. Moreover, he must do this not only correctly but promptly. If he stand poring over the prescription for too long a time, it may induce a suspicion on the part of the customer, that either he is ignorant or the physician careless. Nothing should be done that could possibly tend to weaken the confidence of the patient in prescriber or dispenser.

The prescription should be first looked over with the view of determining certain leading points, the knowledge of which will greatly facilitate the comprehension of minute details. The questions relating to these points will present themselves somewhat in the following order:—is the medicine intended for internal or external use?—is it to be in the form of a mixture, powder, pill, ointment, or what other form?—what is the quantity ordered, and what the dose? These points being determined, for which a single glance of an experienced

eye will suffice, a more careful examination of every word and symbol must follow, with the view of fixing definitively in the mind, what are the several ingredients ordered, and the directions with reference to them. Should a doubt arise in deciphering the names of any of the ingredients, the knowledge of the purpose, form, and method of administering the medicine, will aid in the decision of such points, by affording suggestions as to what would be suitable and what inappropriate. It is much better to meet any difficulty that might arise with the previous knowledge of every attainable fact that could assist the judgment, rather than to seek these aids after an erroneous idea has been impressed upon the mind. In deciphering the writing, it will often be found advantageous to compare the characters in a doubtful word with those most nearly resembling them in some part of the prescription which is intelligible. Should the difficulty still remain, the opinion of a second party, when attainable, should be sought; and in doing this, let not false pride prevent the inquiry being made from those who are capable of judging. Such inquiries, however, should not be made, if it can be avoided, in the presence of the customer.

Sometimes a word may occur in a prescription which is quite legible, but the meaning of which is not understood, in which case reference should be made to a dictionary, or other book, in which the terms used in prescriptions are explained, and in this case, again, it should be done without exciting the suspicion of the customer that any doubt exists as to the meaning of the prescription.

If, after adopting all these means, it be still found impossible to read or to comprehend the instructions contained in the prescription, it will be the duty of the dispenser to ascertain who the prescriber is, and to apply to him for an explanation.

But difficulties such as we have here contemplated are of rare occurrence. There is generally no difficulty that an experienced dispenser does not easily overcome in reading and understanding prescriptions.

If the medicine be waited for, let as little delay as possible occur before the preparation of it is commenced. A good and accomplished dispenser will make it his study to inspire a belief that he quickly comprehends and promptly executes the orders which are entrusted to him.

While the prescription is in course of preparation it should be placed in such a position that the operator can read it while he is dispensing the medicine. A small stand is sometimes provided for this purpose, on which the prescription is secured by means of a paper-

weight, and being thus elevated, it is not liable to be soiled by any liquid that might be spilled over the counter.

[Fig. 472 represents the kind of stand that I have found most useful for common use. It is turned from a piece of mahogany or walnut, the base loaded with lead, and a pointed wire inserted above. This stand is intended for the prescriptions of each day, they being removed to the file every morning.

In the United States, where the medical corps contains physicians from many of the schools of continental Europe, who often prescribe with a view to the preparations of their vernacular Pharmacopœias, the pharmacist labours under peculiar difficulties. Prescriptions in German and French are sometimes seen; and the wretched characters in which a large number of prescriptions are couched, add greatly to the other perplexities of the dispenser. Long practice, which gives familiarity with a great variety of handwriting, will enable one to overcome, in a great degree, the ill effects of the careless chirography of medical men. But to meet the difficulties arising from prescribing the preparations of foreign Pharmacopœias, the apothecary must not only be acquainted with the official lists of those authorities, but should have in his possession several good books of reference, which may include the French Codex, Jourdan's Universal Pharmacopœia, Gray's Supplement, Soubeiran's or Guibourt's Pharmacy, and Pereira's Materia Medica, in addition to our own standard authorities. It is a good practice to keep a book in which extraordinary prescriptions may be recorded, and some notice taken of their contents, or the manipulations they may require, in a systematic manner. Such a record will in time prove a valuable store of information, pregnant with usefulness in difficult cases.

The use of Latin terms for the directions of prescriptions, has almost fallen into disuse in this country, and a knowledge of Latin is not made an indispensable requisite of pharmaceutical education. Nevertheless, prescriptions are occasionally presented clothed in a classic garb, and it has been deemed useful to introduce the following table of contractions of Latin medical phrases, from Gray's Supplement, to assist those who are not versed in that language.—W. P.]

Fig. 472.



PRESCRIPTION STAND.

[EXPLANATION OF TERMS USED IN PRESCRIPTIONS.]

A, aa, ana (Greek) of each. It signifies equally by weight or by measure.

Abdom., *abdomen*, the abdomen, the belly.

Abs. febr., *absente febre*, fever being absent.

Ad. 2 vic., *ad secundam vicem*, to the second time ; or *ad duas vices*, for two times.

Ad. gr. acid., *ad gratam aciditatem*, to an agreeable acidity.

Ad def. animi, *ad defectionem animi*, to fainting.

Ad del. an., *ad deliquium animi*, to fainting.

Ad libit., *ad libitum*, at pleasure.

Add., *adde*, or *addantur*, add, or let them be added ; *addendus*, to be added.

Adjac., *adjacens*, adjacent.

Admov., *admove*, *admoveatur*, *admoveantur*, apply, let it be applied, let the *u* be applied.

Ads. febre, *adstante febre*, while the fever is present.

Alter. hor., *alterius horis*, every other hour.

Alvo adstr., *alvo adstrictâ*, when the bowels are confined.

Aq. astr., *aqua astricta*, frozen water.

Aq. bull., *aqua bulliens*, boiling water.

Aq. com., *aqua communis*, common water.

Aq. fluv., *aqua fluviatilis*, river water.

Aq. mar., *aqua marina*, sea water.

Aq. niv., *aqua nivalis*, snow water.

Aq. pluv., *aqua pluviatilis*, or *pluvialis*, rain water.

Aq. ferr., *aqua fervens*, hot water.

Aq. font., *aqua fontana*, or *aqua fontis*, spring water.

Bis ind., *bis indicis*, twice a day.

Bib., *bibe*, drink.

BB., *Bbds.*, *Barbadensis*, Barbadoes, as *aloë Barbadensis*.

B.M., *balneum marie*, or *balneum maris*, a warm-water bath.

But., *butyrum*, butter.

B.V., *balneum vaporis*, a vapour bath.

Cærul., *cæruleus*, blue.

Cap., *capiat*, let him (or her) take.

Calom., *calomelas*, calomel, protochloride of mercury.

C. C., *cornu cervi*, hartshorn ; it may also signify *cucurbitula cruenta*, the cupping-glass with scarificator.

C. C. U., *cornu cervi ustum*, burnt hartshorn.

Cochleat., *cochleatim*, by spoonful.

Coch. ampl., *cochleare amplum*, a large (or table) spoonful; about half a fluid ounce.

Coch., *infant.*, *cochleare infantis*, a child's spoonful.

Coch. magn., *cochleare magnum*, a large spoonful.

Coch. med., *cochleare medium*, } a middling or moderate spoonful;
Coch. mod., *cochleare modicum*, } that is, a dessert spoonful—about
 two fluid drachms.

Coch. parv., *cochleare parvum*, a small (or tea) spoonful; it contains about one fluid drachm.

Col., *cola*, strain.

Col., *colatus*, strained.

Colet., *coletur*, *colat.*, *colatur*, let it be strained; *colaturæ*, to the strained liquor.

Colent., *colentur*, let them be strained.

Color., *coloretur*, let it be coloured.

Comp., *compositus*, compounded.

Cong., *congius*, a gallon.

Cons., *conserva*, conserve; also (*imperat. of conservo*) keep.

Cont., *rem.*, or *med.*, *continuentur remedia*, or *medicamenta*, let the remedies, or the medicines, be continued.

Coq., *coque*, boil; *coquantur*, let them be boiled.

Coq. ad. med. consumpt., *coque* or *coquatur ad medietatis consumptionem*, boil, or let it be boiled to the consumption of one-half.

Coq. S. A., *coque secundum artem*, boil according to art.

Coq. in S. A., *coque in sufficiente quantitate aquæ*, boil in a sufficient quantity of water.

Cort., *cortex*, bark.

C. v., *cras vespere*, to-morrow evening.

C. m. s., *cras mane sumendus*, to be taken to-morrow morning.

C. n., *cras nocte*, to-morrow night.

Crast., *crastinus*, for to-morrow.

Cuj., *cujus*, of which.

Cujusl., *cujuslibet*, of any.

Cyath. theæ, *cyatho theæ*, in a cup of tea.

Cyath., *cyathus*, vel } a wine-glass; from an ounce and a half
C. vinar., *cyathus vinarius*, } to two ounces and a half.

Deaur. pil., *deaurantur pilulæ*, let the pills be gilt.

Deb. spiss., *debita spissitudo*, due consistence.

Dec., *decanta*, pour off.

Decub. hor., *decubitús horâ*, at the hour of going to bed, or at bedtime.

De d. in d., *de die in diem*, from day to day.

Deglut., *deglutiatur*, let it be swallowed.

Dej. alv., *dejectiones alvi*, stools.

Det., *detur*, let it be given.

Dieb. alt., *diebus alternis*, every other day.

Dieb. tert., *diebus tertiis*, every third day.

Dil. dilue., *dilutus*, dilute (thin), diluted.

Diluc., *diluculo*, at break of day.

Dim., *dimidius*, one-half.

D. in 2 plo., *deter in duplo*, let it be given in twice the quantity.

D. in p. æq., *dividatur in partes æquales*, let it be divided in equal parts.

D. P., *directione propria*, with a proper direction.

Donec alv. bis dej., *donec alvus bis dejecerit*, until the bowels have been twice opened.

Donec alv. sol. fuer., *donec alvus soluta fuerit*, until the bowels have been loosened.

Donec dol. neph. exulav., *donec dolor nephriticus exulaverit*, until the nephritic pain has been removed.

D., *dosis*, a dose.

Eburn., *eburneus*, made of ivory.

Ed., *edulcorata*, edulcorated.

Ejusd., *ejusdem*, of the same.

Elect., *electuarius*, an electuary.

Enem., *enema*, a clyster.

Exhib., *exhibeatur*, let it be administered.

Ext. sup. alut. moll., *extende super alutam mollem*, spread upon soft leather.

F., *fac*, make; *fiat*, *fiant*, let it be made, let them be made.

F. pil., *fiant pilulæ*, let pills be made.

Fasc., *fasciculus*, a bundle.

Feb. dur., *febre durante*, during the fever.

Fem. intern., *femoribus internis*, to the inside of the thighs.

F. venæs., *fiat venæsectio*, let venesection be performed.

F. H., *fiat haustus*, let a draught be made.

Fict., *fictilis*, earthen.

Fil., *filtrum*, a filter.

Fist. arm., *fistula armata*, a clyster-pipe and bladder fitted for use.

Fl., *fluidus*, fluid.

- F. L. A.*, *fiat lege artis*, let it be made by the rules of art.
- F. M.*, *fiat mistura*, let a mixture be made.
- F. S. A.*, *fiat secundum artem*, let it be made according to art.
- Gel. quav.*, *gelatina quavis*, in any jelly.
- G. G. G.*, *gummi guttæ gambæ*, gamboge.
- Gr.*, *granum*, a grain; *grana*, grains.
- Gr. vi. pond.*, *grana sex pondere*, six grains by weight.
- Gtt.*, *gutta*, a drop; *guttæ*, drops.
- Gtt. quibusd.*, *guttis quibusdam*, with some drops.
- Guttat.*, *guttatim*, by drops.
- Har. pil. sum. iij.*, *harum pilularum sumantur tres*, of these pills let three be taken.
- H. D.*, or *hor. decub.*, *horâ decubitûs*, at bed-time.
- H. P.*, *haustus purgans*, purging draught.
- H. S.*, *horâ somni*, at the hour of going to sleep.
- Hor. un. spatio*, *horæ unius spatio*, at the expiration of one hour.
- Hor. interm.*, *horis intermediis*, in the intermediate hours.
- Hor. 11mâ. mat.*, *horâ undecimâ matutinâ*, at 11 o'clock in the morning.
- Ind.*, *indies*, daily.
- In pulm.*, *in pulmento*, in gruel.
- Inf.*, *infunde*, infuse.
- Jul.*, *julepus*, *julapium*, a julep.
- Inj. enem.*, *injiciatur enema*, let a clyster be thrown up.
- Kal. ppt.*, *kali præparatum*, prepared kali (*potassæ carbonas*, Ph. L.)
- Lat. dol.*, *lateri dolenti*, to the affected side.
- M.*, *misee*, mix; *mensurâ*, by measure; *manipulus*, a handful; *minimum*, a minim.
- Mane pr.*, *mane primo*, early in the morning.
- Man.*, *manipulus*, a handful.
- Min.*, *minimum*, a minim, the 60th part of a drachm measure.
- M. P.*, *massa pilularum*, a pill mass.
- M. R.*, *mistura*, a mixture.
- Mic. pan.*, *mica panis*, crumb of bread.
- Mitt.*, *mitte*, send; *mittantur*, let them be sent.
- Mitt. sang. ad 3xij.*, *mitte sanguinem ad 3xij.*, take blood to twelve ounces.
- Mod. præser.*, *modo præscripto*, in the manner directed.
- Mor. diet.*, *more dicto*, in the way ordered.
- Mor. sol.*, *more solito*, in the usual way.

Ne tr. s. num., ne tradas sine nummo, do not deliver it without the money.

N. M., nux mosehata, a nutmeg.

No., numero, in number.

O., octarius, a pint.

Ol. lini s. i., oleum lini sine igné, cold-drawn linseed oil.

Omn. hor., omni horâ, every hour.

Omn. bid., omni biduo, every two days.

Omn., bih., omni bihorio, every two hours.

O. M., or omn. man., omni mane, every morning.

O. N., or omn. noct., omni nocte, every night.

Omn. quadr. hor., omni quadrante horæ, every quarter of an hour.

O. O. O., oleum olivæ optimum, best olive oil.

Ov., ovum, an egg.

Oz., the ounce avoirdupois, or common weight, as contradistinguished from that prescribed by physicians.

P. æ. part. æqual., partes æquales, equal parts.

P. d., per deliquium, by deliquescence.

Past., pastillus, a pastil, or ball of paste.

P., pondere, by weight.

Ph. D., Pharmacopœia Dubliniensis.

Ph. E., Pharmacopœia Edinensis.

Ph. L., Pharmacopœia Londinensis.

Ph. U. S., Pharmacopœia of the United States.

Part. vic., partitis vicibus, in divided doses.

Per. op. emet., peractâ operatione emetici, the operation of the emetic being over.

Pocul., poculum, a cup.

Pocill., pocillum, a small cup.

Post sing. sed. liq., post singulas sedes liquidas, after every loose stool.

Ppt., præparata, prepared.

P. r. n., pro re nata, occasionally.

P. rat. ætat., pro ratione ætatis, according to the age.

Pug., pugillus, a pinch, a gripe between the thumb and the two first fingers.

Pulv. pulvis, pulverizatus, a powder, pulverized.

Q. l., quantum libet, } as much as you please.
Q. p., quantum placet, }

Q. s., quantum sufficiat, as much as may suffice.

Quor., quorum, of which.

- Q. V.*, *quantum vis*, as much as you will.
- Red. in pulv.*, *redactus in pulverem*, reduced to powder.
- Redig. in pulv.*, *redigatur in pulverem*, let it be reduced into powder.
- Reg. umbil.*, *regio umbilici*, the umbilical region.
- Repet.*, *repetatur*, or *repetantur*, let it, or them, be repeated.
- S. A.*, *secundum artem*, according to art.
- Scat.*, *scatula*, a box.
- S. N.*, *secundum naturam*, according to nature.
- Semidr.*, *semidrachma*, half a drachm.
- Semih.*, *semihora*, half an hour.
- Sesunc.*, *sesuncia*, half an ounce.
- Sesquih.*, *sesquihora*, an hour and a half.
- Si n. val.*, *si non valeat*, if it does not answer.
- Si op. sit.*, *si opus sit*, if it be necessary.
- Si vir. perm.*, *si vires permittant*, if the strength allow it.
- Signat.*, *signatura*, a label.
- Sign. n. pr.*, *signetur nomine proprio*, let it be written upon, let it be signed with the proper name, (not the trade name.)
- Sing.*, *singulorum*, of each.
- S. S. S.*, *stratum super stratum*, layer upon layer.
- Ss.*, *semis*, a half.
- St.*, *stet*, let it stand; *stent*, let them stand.
- Sub fin. coct.*, *sub finem coctionis*, towards the end of boiling, when the boiling is nearly finished.
- Sum. tal.*, *sumat talem*, let the patient take one such as this.
- Summ.*, *summitates*, the summits or tops.
- Sum.*, *sume*, *sumat*, *sumatur*, *sumantur*, take, let him or her take, let it be taken, let them be taken.
- S. V.*, *spiritus vini*, spirit of wine.
- S. V. R.*, *spiritus vini rectificatus*, rectified spirit of wine.
- S. V. T.*, *spiritus vini tenuis*, proof spirit.
- Tabel.*, *tabella*, a lozenge.
- Temp. dext.*, *tempori dextro*, to the right temple.
- T. O.*, *tinctura opii*, tincture of opium.
- T. O. C.*, *tinctura opii camphorata*, camphorated tincture of opium.
- Tra.*, *tinctura*, tincture.
- Ult. præser.*, *ultimo præscriptus*, last prescribed.
- V. O. S.*, *vitello ovi solutus*, dissolved in the yolk of an egg.
- Vom. urg.*, *vomitione urgente*, the vomiting being troublesome.
- V. S. B.*, *venæsectio brachii*, bleeding from the arm.
- Zz.*, *zingiber*, ginger.

SYMBOLS USED IN PRESCRIPTIONS.

R, *recipe*, take. This sign is really a modification of the symbol \mathcal{J} , which was the old heathen invocation to Jupiter, imploring his blessing on the prescription.

gr., *granum*, a grain, the 60th part of a drachm.

℞, *scrupulus*, or *scrupulum*, a scruple = 20 grains troy.

ʒ, *drachma*, a drachm = 3 scruples.

℥, *uncia*, an ounce troy.

℔, *libra*, a pound weight.

℥, *minimum*, a minim, the 60th part of a fluid drachm.

f ʒ, *fluidrachma*, a fluid drachm, the 8th part of a fluid ounce.

f ℥, *fluiduncia*, a fluid ounce, the 20th part of a pint.

O, *octarius*, a pint, the 8th part of a gallon.

C, *congius*, a gallon.

MIXTURES—DRAUGHTS—DROPS.

Mixtures.—The term *mixture* is generally applied to a liquid medicine, not intended for local application, which is administered by the mouth in an undiluted state, and of which the bottle in which it is dispensed contains more than one dose. It is a very common form for the administration of medicines.

Mixtures intended for adults usually measure four, six, or eight ounces. Sometimes, however, they extend to a pint or even a quart. When intended for children the quantity is generally from an ounce to four ounces.

The ingredients which usually enter into the composition of mixtures are salts and other solid bodies which are soluble in or easily miscible with aqueous menstrua, together with tinctures, spirits, syrups, infusions, decoctions, and distilled waters.

In preparing a mixture, the dispenser has to consider how he can best effect the solution of solid substances which are soluble; the equal diffusion of those which are insoluble, throughout the menstruum; and the intimate admixture of all the ingredients of whatever kind, so that every dose, when taken, shall be of similar composition.

It is not necessary, nor is it always desirable, or even practicable, to mix the ingredients in the order in which they are named in the

prescription. The dispenser is expected to exercise his judgment in determining the best method of effecting the combination. Sometimes the ingredients require to be mixed in a mortar; in this case, of course, a Wedgwood's mortar would be employed. The mortar should not be used, however, unless it be necessary.

If all the ingredients consist of liquids which are miscible, they are poured at once from the measure-glass into the bottle, and mixed by agitation. It is customary to measure those ingredients first, the quantities of which are smallest, and to add the most bulky ingredient, which is often a mere menstruum for the others, last. There are cases, however, in which it is desirable to deviate from this course, as for instance, in adding hydrocyanic acid, or other very volatile substances, which should be added last, to prevent loss from evaporation.

When salts, or other substances readily soluble in the principal menstruum, are ordered, their solution may frequently be effected quite as well in the bottle as it would be in a mortar. In such case the salts should be used in fine powder, being more easily dissolved when in this state. There are some salts the solution of which is greatly facilitated by the use of warm water. Of this class are alum and sulphate of soda.

Some powders, such as magnesia, which are insoluble, but easily diffused through a liquid, may also be mixed with the liquid ingredients by merely shaking them together in the bottle. In doing this, it is well to introduce a small quantity of liquid before the powder, which will prevent the latter from adhering to the glass.

Powders which do not mix readily with liquids, such as rhubarb or gum, must be triturated in a mortar, commencing the trituration with a small quantity of liquid, and adding more when the powder has been brought to the state of a thin paste.

[The mixture known as "Seudamore's Gout Mixture," consisting of magnesia, Epsom salts, water, and wine of colchicum, has the quality of gelatinizing after standing several days, which sometimes occasions a fear on the part of the patient that the apothecary is in fault. This change appears to be due to the magnesia and Epsom salts, as these alone will cause a gelatinous compound; but the quickness of the change and the consistency of the solidified mixture, depend chiefly on the vegetable matter associated. Tincture of jalap, tincture of gentian and certain infusions, act like the colchicum. It is well in these cases to caution the patient in relation to the nature of the change that is likely to ensue.

When sulphuric ether is directed in a prescription to be rubbed with

spermaceti, with a view to assist its solution in the aqueous vehicle, the spermaceti should be subsequently strained out and not left floating in the mixture.—W. P.]

Extracts and electuaries also require to be rubbed in a mortar with a portion of liquid before putting them into the bottle.

In Germany and other continental countries, liquid as well as solid ingredients are always weighed; in this country the quantities of liquids are apportioned by measure, which is a much more convenient practice. Even should the letter indicating the prefix *fluid* be omitted in the symbol by which the quantity of a liquid is expressed, we should understand it to mean a measured quantity. Thus, 3j of a tincture, spirit, or syrup, would be construed to mean a fluid drachm, and not a drachm by weight.

The bottles used for putting medicines into are made of certain definite sizes, such as f3vj, f3vij, f3x, f3xij, &c., and physicians generally regulate the quantities of ingredients ordered in mixtures so as to correspond with the common-sized bottles. Sometimes, however, this point is not observed by the prescriber, and the pharmacist may experience difficulty in finding a bottle that will exactly hold the quantity ordered, especially since moulded bottles have been brought into general use. If a mixture should measure seven ounces, a six-ounce bottle would not hold it, and an eight-ounce bottle would be but partly filled by it. In such case, if a stated proportion of the entire mixture be directed to be taken for a dose, it may be allowable to add a little distilled water, or a little more of the menstruum, if it be inactive, so as to make the quantity more nearly correspond with the capacity of the bottle. This would be not only justifiable but necessary, if the bottle be marked with the divisions of its capacity, as is sometimes the case, to assist the patient in apportioning the dose.

Much perplexity has been caused by the change which has been introduced in the capacity of the pint measure. Medical men sometimes order half a pint or a pint of liquid, under the impression that these quantities are still, as formerly, equivalent to f3vij and f3xvj, whereas the capacity of the pint is now = f3xx. The pharmacist has but one safe and straightforward course to pursue in these cases. In the absence of specific instructions to the contrary, his text-book and guide is the Pharmacopœia, and according to this authority the symbols Oj, and Oss, are synonymous with f3xx, and f3x, [Imperial measure.]

Draughts.—The *draught* differs only from the mixture in being dispensed in bottles, each of which contains but one dose. The practice of ordering medicines, which are taken repeatedly, in the form of

draughts, is not now so common as it was formerly. Such medicines are now more frequently prescribed in the form of mixture. There are some cases, however, in which there is decided advantage in having medicines put up in draughts. Such is the case when it is important that the doses should be very carefully apportioned, and also when the medicine is liable to undergo change from the action of atmospheric air. Thus, for instance, the *Mistura Ferri composita*, if dispensed in the form of mixture, will undergo continued and rapid change after the first dose has been taken out of the bottle, the protocarbonate of iron passing to the state of peroxide; whereas, if it be dispensed in draughts, and the bottles be filled and well corked, no such change will occur. The quantity of liquid contained in a draught usually varies from f3x to f3xiv; sometimes, however, it amounts to f3ij. The vials used for dispensing draughts in, should be kept sorted, of several different sizes, such as f3x, f3xij, and f3xiv.

It is customary, when a prescription directs that a draught shall be taken twice a day, or three times a day, to send a sufficient supply for two days, unless there be express instructions to the contrary. If, however, the draught be taken only once a day, a supply for three days may be sent, if the medicine will keep good for that time.

The requisite number of vials, of the proper size, are in the first place selected, and it is desirable that these should correspond as nearly as possible, not only in capacity, but also in length and general appearance. The vials are put into the *draught-stand*, and the operator, in the next place, proceeds to mix the ingredients for the draughts. The instructions which have been given with reference to the dispensing of mixtures, will not apply, in some respects, to the preparation of draughts. It is not customary to weigh and measure the ingredients for each draught separately; consequently the solution of salts, and the admixture of easily diffusible solid substances cannot be effected in the bottles. The principal ingredients for the whole number of draughts are mixed in a measure-glass of sufficient capacity, a mortar being used, if necessary, for promoting solution or intimate admixture, of solids; and to these as much of the menstruum, or least active constituent, is added, as will about half fill the vials. This mixture is poured into the vials, and equally divided between them, the correctness of the division being determined by the eye of the operator; and the vials are then filled up with the remaining part of the menstruum. It is necessary, in thus operating, to be careful that all soluble solids are completely dissolved before commencing the division of the mixture, and that insoluble substances are kept constantly

suspended while the division is effected. If there should be any powder ordered in the draughts which cannot be kept suspended while the mixture is apportioned to the several vials, it will be necessary to weigh this out and introduce it into the vials separately.

After filling the vials each to an equal extent, they are corked and capped with paper. The operation of tying on the caps will be most expeditiously and elegantly effected by means of the *capping-knot*, which is described at page 429.

The vials, thus far prepared, are to be wiped with a clean cloth; the directions for taking them are to be attached to one, which is distinguished from the others by being wrapped in a paper which extends only half-way up the shoulder of the bottle, leaving the label partly uncovered, while each of the others is entirely enveloped in a wrapper; and finally the whole of them are enclosed in a wrapper so as to form a neat parcel. If there be three draughts, they are placed side by side in the parcel; four draughts are placed in two layers each consisting of two; and six draughts form two layers, each consisting of three.

Drops.—If a medicine consist of tinctures, spirits, or other similar preparation, the dose of which is a teaspoonful or less, if it be diluted when administered, and the intended application of it be similar to that of a mixture, it is generally distinguished by the name of *drops*.

No particular instructions are necessary in the preparation of drops, unless it be where some solid substance has to be dissolved.

Drops generally consist of clear solutions, and of more or less active medicines. If the medicine should be sent to a patient with any soluble substance in an imperfectly dissolved state, an unfavourable impression with regard to the carefulness and attention of the dispenser might be produced. The pharmacist has, therefore, to exercise his judgment, in producing at once such a state of combination as will be permanent. Thus, if *disulphate of quina* should be a constituent either of drops or a mixture, its solution being promoted by the addition of diluted sulphuric acid, the acid should not be added immediately to the salt, as in this case a compound would be formed which would be very slowly dissolved, whereas, if the salt be first diffused through a little liquid, and the acid then added, the solution will take place immediately.

EMULSIONS.

An *emulsion* is a mechanical mixture, having a milky appearance, of an oil, fat, or resin, with water, the admixture being promoted and

rendered more or less permanent, by the presence of an alkali or gum, or some equivalent substance, such as albumen or caseine.

The milk of animals, as a natural production, may be considered a good type of this class of preparations. In this case, the fat or butter is diffused through an aqueous liquor, and held in suspension by the presence of caseine, sugar, and alkaline salts. The milky juices of plants present other instances of emulsions existing ready formed in nature.

The emulsions used in medicine, are produced by artificial means, but in their leading characters they resemble those met with in nature. They are formed, either by triturating certain seeds, which contain the necessary constituents for the production of an emulsion, with water; or by mixing the separate ingredients directly with each other, in such a way as to effect the desired object.

The most simple and easy method of forming an emulsion is, by triturating some suitable seeds, such as those of the almond, with water. Almond emulsion is thus made. The almonds being first deprived of their skins, by immersing them in hot water until the skins are loose, and then pressing them between two fingers, are bruised in a Wedgwood's mortar, a little water being added, from time to time, to prevent the separation of oil, which otherwise would take place. When the almonds have been well comminuted and formed into a thin paste with water, by pounding and trituration, the remainder of the water is added to form the emulsion, and this is subsequently strained to separate the woody fibre of the seeds. The fixed oil of the almond forms the emulsion through the intervention of a portion of gum, and more especially of an albuminous constituent called emulsin, both of which are contained in the seed. Other seeds, besides those of the almond, may be used for making emulsions. In Germany, the poppy-seed is frequently employed for this purpose.

[Castor beans, when deprived of their episperm, may be triturated with water, and form a good emulsion, and an efficient medicine, which has been recommended as being far less nauseous than that made from the oil itself.—W. P.]

Emulsions are made with gum-resins, such as *myrrh*, *ammoniacum*, and *assafatida*, in a similar way to that described for making almond emulsion. The gum-resin is first bruised in a mortar, then triturated with a small quantity of water, and finally diluted with the remainder of the water, and strained or decanted from the insoluble residue. Good specimens of the gum-resins should be selected for this purpose. In selecting *myrrh* for making emulsions, those pieces only should be

used which, when broken, present a milky appearance within. Powdered myrrh should never be used.

Emulsions are sometimes made with *expressed oils and an alkali*. One of the most common emulsions, used as a simple remedy for cough, is formed by agitating some oil of almonds with solution of potash or spirit of ammonia and water. This is the first case in which we shall have to consider the method of operating when the separate ingredients have to be mixed by artificial means for the production of an emulsion. Six drachms of oil of almonds, one drachm of solution of potash, and five ounces of distilled water, will form a good emulsion, if mixed in the proper way. It is not sufficient, however, to put these substances together and shake them or triturate them: there is a certain order and proportion in which they must be mixed. The best method of proceeding is, to put the oil into the bottle with rather less than its volume of water; to add the alkali to these, and shake them well together. An intimate admixture, of a perfectly milky character, is thus obtained, which may be diluted with the remainder of the water so as to form a good emulsion. If much water were put into the bottle in the first instance, or if the oil alone were shaken with the solution of potash in an undiluted state, the result would not be equally satisfactory.

Emulsions are frequently made with expressed oils or oleo-resins and mucilage. Castor oil and balsam of copaiba are often made into emulsions in this way. Much more art is required in making the emulsion of copaiba than that of castor oil, and a description of the method of proceeding, when the former of these substances is used, will, therefore, serve to illustrate the means most conducive to success in either case.

The mucilage used for making copaiba into an emulsion, ought to be rather thicker than that made according to the Pharmacopœia. On this account, and also with the view of obviating the chance of any acid, caused by fermentation, being present in the mucilage, it is better to use powdered gum-arabic. If mucilage be ordered, one-third the quantity of gum may be substituted. One drachm of gum will suffice for three drachms of the oleo-resin, and these may be formed into an emulsion with five or six ounces of water, in the following way. The gum is first triturated with a little water, in a Wedgwood's mortar, so as to form a thick mucilage; to this a few drops of the copaiba are added, and the trituration is continued until the ingredients are completely mixed. More of the copaiba is then put in, and the trituration maintained, until the mixture assumes the con-

dition of a thick emulsion. This must now be diluted with a little water (3ss or 3j), before adding more copaiba. Without this dilution the mixture would assume a condition in which it would no longer mix with water. When the whole of the copaiba has been mixed in, with sufficient water to prevent it from becoming too thick, the remainder of the water may be added. Tincture or other ingredients should not be introduced until the emulsion has been completely formed.

If, instead of adding the oil gradually to the mucilage, the mucilage were added to the oil, a good emulsion would not be formed; and, although it is desirable on commencing the admixture to have the mucilage rather thick, yet, after part of the oil has been incorporated, some degree of dilution becomes necessary.

Mucilage answers better than an alkali for making an emulsion with castor oil or copaiba, but the alkali forms the best emulsion with oil of almonds. A good emulsion formed with either of these agents alone, is often caused to separate if the other be added. Thus, the emulsion made with oil of almonds and potash, will lose, in great measure, its milky character, on the addition of mucilage.

The presence of soluble salts in an emulsion generally tends to cause a separation of the oil. Much spirit will produce a similar effect, especially in emulsions made with mucilage; and acids, in those made with alkali. Alkaline salts, however, in small quantity, are beneficial. Thus, a little borax will often be found greatly to improve an emulsion.

There are some substances which cannot be formed into good emulsions with an alkali or with mucilage. Spermaceti and other solid fats belong to this class, and so also does oil of turpentine. In such cases yolk of egg is the best agent for effecting the admixture, the ingredients being rubbed together in a mortar; and, should any difficulty be expected, the oily or fatty body should be added gradually to the yolk of egg, and the mixture diluted with a little water, from time to time, as it thickens.

[Volatile oils are more readily emulsified by previous admixture with a little fixed oil—especially those of the turpentine class, as oil of copaiba, cubebs, cajuput, etc. The yolk of egg owes its advantages over the white, for this purpose, to the fact that it is itself a natural mixture of fixed oil and albumen. A good spermaceti mixture may be made by triturating that substance with half its weight of olive oil, then adding the proper quantity of gum-arabic, and after mixing them, adding the water gradually, in the usual

manner of making an emulsion. Camphor is frequently prescribed in mixtures suspended with mucilage. It is usually pulverized by the addition of alcohol, triturated with the gum in powder, and lastly the water added gradually in the manner of making an emulsion. A much more permanent and better mixture is obtained by triturating the camphor to a uniform paste by the addition of half its weight of olive or almond oil, then adding twice its weight, or more, of powdered gum-arabic, mixing intimately, and adding the water gradually, triturating constantly till the whole is mixed.

One of the best ways to make a camphor mixture, when the addition is not contraindicated, is by means of myrrh. One part of that gum-resin will suspend four parts of camphor. The tears richest in volatile oil should be chosen, as in making an emulsion of myrrh, the camphor should be powdered by the addition of a little alcohol, and added to the myrrh previously reduced to a milky paste with water, the two then triturated until uniformly mixed, after which the water is gradually added.

When a few drops of croton oil are directed to be suspended in mucilage, it is well to admix a little olive oil, so as to increase its quantity and render the emulsion more permanent.—W. P.]

Scammony mixes very readily into an emulsion with a little milk; and resin of jalap, which will not mix with milk, may be diffused through emulsion of almonds by triturating it with the almonds and water.

POWDERS.

Very little art is involved in dispensing powders.

If a prescription should order a powder, which is directed to be taken repeatedly at stated periods, a sufficient supply for two, three, or more days, is usually sent, unless there be instructions to the contrary, or some special reason for deviating from this course.

When several powders have to be dispensed from a formula in which the proportions for one powder are given, it is customary to mix the ingredients for the whole number together, and subsequently to divide the aggregated powder into its appropriate parts.

The ingredients of powders are mixed in a Wedgwood's mortar, or on a piece of smooth paper. As a general rule, a mortar should be used excepting when the ingredients constitute but one dose, or when the quantity mixed is so small that it is necessary to avoid losing the portion that would adhere to the mortar and pestle. It is

important in all cases that the admixture of the ingredients should be effected as completely as possible, and more especially when, as is often the case,* the ingredients are of very unequal degrees of activity.

The order in which the several substances to be mixed are put into the mortar, should be the reverse of that which is adopted in introducing the ingredients of a mixture into the bottle. Instead of beginning with the least bulky ingredient, the most bulky, or it should rather be said, the most inactive, ingredient, should be put in first, and the more active on to the top of this. The object in adopting this mode of proceeding is, to avoid as much as possible the loss of any part of the active ingredients by their being taken up in the pores of the mortar. The mixture is effected by trituration with the pestle, and this should be continued for a sufficient length of time to insure the perfect distribution of the ingredients. If there should be a large quantity of an inactive powder, and a very small quantity of an active ingredient, it may be desirable to put only a part of the former into the mortar, and placing the active ingredient on the top of it, to effect their intimate admixture before introducing the remainder of the inactive powder. So, also, if the powders to be mixed should differ much in specific gravity, and the quantities to be mixed be large, it would be desirable to put only a part of the lightest powder in first, and after that has been mixed with the other ingredients, to add the remainder.

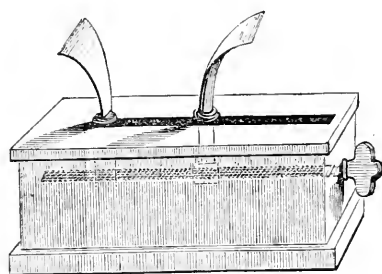
[Substances of various texture and density are associated in prescriptions, as crystals, gum-resins, leaves, and roots, and as it is a common custom with the majority to pulverize many of the substances after they are weighed, some care and judgment should be exercised as to the order of their introduction into the mortar. When camphor is to enter powders, it should be first thoroughly broken up by the addition of spirit of wine, then if any other substances require trituration, it is removed from the mortar, and these are reduced to powder. The camphor is then returned, and by a gentle rotary movement of the pestle, the associated powder is mixed with it, without much pressure at first, so as to avoid conglomerating the camphorous particles before they are covered with the other powder. When morphia or opium is associated with camphor, in powders, if the physician has directed no gum or sugar in the prescription, the apothecary should triturate the morphia or opium with a little gum-arabic, and add the camphor to it as directed above. It is not easy to make opium and camphor into powders without this or some other addition.—W. P.]

After effecting the due admixture of the ingredients, if they are to

be divided into several separate doses, the papers for their reception are spread out on the counter, and the powder is distributed to each on the point of the knife. The equality of the division is generally determined by the eye of the operator, but as some persons are incapable of distinguishing differences of quantity with sufficient accu-

raey by the eye, the use of the balance should in such cases be resorted to.

There are some powders containing volatile ingredients, which are advantageously enclosed in waxed paper. [Tin-foil is also appropriate, and either it or waxed paper should be used in powders containing camphor or carbonate of potassa. It is better that each powder, if



POWDER-FOLDER.

several are prescribed, should be enveloped separately.

The paper used for powders should be glazed if possible, at all events very smooth, so as to prevent the adherence of the powder.—W. P.]

When a powder consisting of several doses, is sent out, undivided, the patient being left to apportion the dose on taking it, it should always, unless otherwise desired, be put into a wide-mouthed bottle.

ELECTUARIES—CONSERVES—LINCTUS.

The *electuary* or *confection* is a very ancient form for the administration of medicines. It consists of solid substances which are brought to the condition of a thin paste by admixture with some saccharine or mucilaginous liquid.

The *conserve* is a preparation, similar in consistence to the electuary or confection. The names seem to indicate that in the conserve (*conservo*, to keep,) the saccharine matter is used for the purpose of preserving the substance to which it is added, while in the confection (*conficio*, to make up,) the saccharine liquid is added only to impart convenience of form.

The *linctus* differs from the two preceding forms in being made thinner. The name appears to be derived from the word *lingo*, to lick, the consistence being such that it can be licked from a spoon.

These forms of medicine are very rarely prescribed in the present day, and no particular directions are required for their preparation.

LOZENGES.

The *lozenge* is a very common and convenient form for those medicines which are intended to act, by continued application, on the pharynx and upper part of the trachea.

A great variety of lozenges are kept by the pharmacist, but these are almost always made by the confectioner. Sometimes, however, the pharmacist has occasion to prepare medicines of this kind himself.

Lozenges may be divided into three classes:—

1st. Those, the principal basis of which is sugar, and in the preparation of which the ingredients are combined without the aid of heat. The application of the term *lozenge* is sometimes confined to these.

2d. Those, the principal basis of which is sugar, and which in their preparation are rendered fluid by means of heat. These are sometimes distinguished by the name of *drops*.

3d. Those which retain a permanently soft and pasty consistence, their principal basis being generally a vegetable juice or pulp. These are usually called *pastes*.

1. *Lozenges*.—In making the first class of lozenges, the sugar is employed in powder; other more active ingredients are added, in the state either of powder or liquid; and the mixture is formed into a tenacious paste with the addition of some liquid, either water or mucilage.

The liquid which appears to answer best for making lozenges is mucilage of tragacanth. This is made from the best gum tragacanth, which should be carefully picked to insure the absence of any foreign matter that might discolour the lozenges. The gum, which should not be used in the state of powder, is mixed with eight or ten times its weight of distilled water, and allowed to stand in a warm place for a day or two. It is then strained through a cloth, and subsequently beaten up in a mortar.

The sugar being mixed with the other ingredients, the mixture is made into a stiff paste with the mucilage. Sometimes part of the sugar is mixed with the powder or other active ingredients of the lozenges, while the remainder of the sugar is made into a thin paste with the mucilage, and then the two mixtures are incorporated.

The paste is rolled out on a marble slab, some powdered starch being used to prevent adhesion to the slab or to the roller. A frame of wood or iron, of the thickness of a lozenge, is placed on the slab,

so that by rolling out the paste until the roller comes on to the frame, the paste will have a uniform and proper thickness.

The lozenges are cut out of the extended paste by a small tin-plate punch, which gives them the required shape and size. They are then placed on sieves in a drying-room or closet until they become hard and dry.

[Lozenges which contain much extract of liquorice and gum-arabic, with sugar, have a peculiar tough consistence, which unfits the mass for the manipulation required by ordinary lozenges. Wistar's lozenges may be instanced. In making these, the opium should be intimately mixed with the liquorice and gum, the oil of anise added, and also mixed, when the sugar, in the form of a dense syrup, made with but two-thirds of the usual quantity of water required for simple syrup, should be quickly admixed, and the mass, whilst yet warm, rolled into long cylindrical rolls like refined liquorice, and when partially dried, cut up into lengths, weighing ten grains each. It will be found advantageous to mix the mass in portions of a pound each, if but one operator is engaged, as it is apt to acquire an unmanageable toughness by standing long. Some pharmacutists prefer to mix the sugar in powder with the other ingredients, and make the mass with water. When so made it has less tendency to become tough, but unless the sugar is in very fine powder, the texture of the lozenges made in this way is not so smooth as by the first-mentioned plan with heat.—W. P.]

2. *Drops*.—In making the second class of lozenges, commonly called *drops*, the sugar is used in coarse powder, all the finest particles having been removed by means of a sieve. A little water or other liquid, such as the formula may direct, and also any ingredients intended for colouring or flavouring the drops, are added to the sugar so as to moisten it. A portion of this mixture is put into a small pan furnished with a lip and suitable handle, and this is placed over a clear fire until the sugar has melted. The pan is now removed from the fire, and the melted mixture is allowed to drop, in quantities sufficient to form masses of the required size, on to a greased iron or tin plate. The drops are allowed to harden, and are then removed.

3. *Pastes*.—The third class of lozenges usually consist of insipidated juices, or decoctions, to which gum, sugar, and other ingredients are added. They are brought to the proper consistence, either by the application of heat, and then poured into flat tin moulds, or they are mixed without heat, and rolled out on a marble slab, in the manner already described.

CHAPTER XVII.

EXTEMPORANEOUS PHARMACY.

PILLS, CAPSULES, GARGLES, ENEMAS, INJECTIONS, LOTIONS, LINIMENTS, EMBROCATIONS, OINTMENTS, SUPPOSITORIES, CATAPLASMS, MOXAS, SPREAD PLASTERS, INHALATIONS.

PILLS.

THERE is probably no form of medicine more frequently prescribed than that of the *pill*. It is a form well adapted for the administration of many medicines, including those of a fetid or nauseous character, those whose specific gravities render them difficult of administration when mixed with liquids; those which are designed to act slowly, such as alteratives, and those, the action of which is desired to be retarded, until the medicine shall reach the lower intestines.

Among the substances which enter into the composition of pills, are the vegetable and other extracts, the resins, gum-resins, balsams, and essential oils. These are more frequently administered in the form of pill than in any other form, and with them are combined many powders and mineral preparations.

The object in forming a pill-mass is to obtain a consistent, firm, and adhering paste, which shall be sufficiently plastic to admit of being moulded without adhering to the mould, and sufficiently stiff to prevent the pills from losing their shape when made into the proper form.

A pill-mass may be said to consist of two essential parts,—the *active ingredients* which enter into its composition, whether of a solid or liquid nature,—and the *excipient*, by which the proper degree of consistence and tenacity are given to the former.

The substances employed as excipients in pill-making are both numerous and of very different natures. The most common are, syrup, mucilage, soap, water, spirit or tinctures, gum, sugar, magnesia, starch, &c.

The principal art in pill-making consists in selecting the proper sub-

stances as excipients to suit the peculiar nature of the other ingredients of the pills.

The pill-mass ought to possess *tenacity* or *adhesiveness*, *firmness*, and *plasticity*; and it will be well to consider what the conditions are upon which these properties depend, and how they are best attained.

The tenacity or adhesiveness of the mass depends upon two principal conditions. The first of these is the presence of a property inherent in the particles of a substance, through which they are readily made to attach themselves to particles of the same, or of a different kind; and the second is, the existence of a certain state of partial fluidity or softness, which appears to promote, and, indeed, to be essential to, that particular kind of tenacity under consideration. Deprive an otherwise adhesive substance of all tendency to fluidity, and you deprive it of its adhesiveness. In order, then, that a body should be tenacious or adhesive, it is necessary that it should have some of its particles in a fluid or semifluid state. Hence, a substance which, when deprived of all tendency to fluidity, possesses no adhesiveness whatever, will sometimes become adhesive on adding a small quantity of some liquid which is capable of acting as a solvent. Resin, when perfectly dry and hard, has no adhesiveness, yet it becomes adhesive on adding a few drops of spirit, which acts as a solvent of some of its particles. Gum, in like manner, which is not adhesive when dry, becomes so on the addition of water. But by this method of adding an excipient which, without possessing any adhesiveness itself, acts simply as a solvent of some of the solid particles present, we can only *develope*,—we cannot *impart* adhesiveness. If the property of adhesiveness be not inherent in the solid substance, the use of an excipient which acts merely as a solvent, will not be sufficient. Thus, the addition of spirit does not render camphor adhesive, because there is none of that property inherent in the camphor. In cases of this kind, therefore, it is necessary to employ *excipients* which *possess* and can *impart* adhesiveness.

Firmness is the next requisite property in the pill-mass—a property not less essential than that of adhesiveness or tenacity. The pill-mass should have a due degree of firmness, so that the pills when formed shall retain their shape. Now, whilst a state of solution or fluidity of some of the particles is essential to adhesiveness, so, on the other hand, the hardness and insolubility of others of the particles is necessary to insure the requisite firmness. These two properties, then, depend upon opposite conditions,—the one, upon partial solution or

fluidity,—the other upon the hardness and insolubility of a part of the ingredients.

The firmness of a pill-mass,—that state in which the pills will retain their shape,—is a very important point to attain in pill-making. The mass may possess the proper degree of adhesiveness, and be of a good consistence for rolling into pills, and yet, from its not having a sufficient proportion of the ingredients in a hard and insoluble state, it may be subject to this serious objection, that the pills made from it will lose their globular form, and perhaps run into one mass in the box. This result will be very likely to occur, if a liquid excipient be employed which is capable of acting as a perfect solvent to every part of the solid ingredients of the pill-mass. Pills formed from a resin perfectly soluble in spirit, and which has been moistened with spirit to form the mass, can hardly be made to retain the globular form, unless the whole, or nearly the whole, of the spirit be again driven off.

The method of proceeding in making pills is similar to that adopted in building a house,—both bricks and mortar must be used,—the bricks to give solidity and firmness, and the mortar to act as a cement in causing the solid particles to adhere together. The condition of pills made from a mass, the whole of which is in a semifluid state, might be compared to that of a house built of nothing but mortar. When, therefore, a pill-mass is in such a state that the pills made from it refuse to retain their shape, it may be inferred that more bricks are required, that is to say, that there is a deficiency of solid, insoluble particles, to give firmness and stability to the structure.

Plasticity is the next and last requisite in the pill-mass. A mass may possess so much firmness—so much hardness—that it will not take the form we wish to give it; or, on the other hand, it may have so large a proportion of the particles in a semifluid condition, that it cannot retain the form which has been given to it. The medium between these two states is the condition required. A mass to be well adapted for making into pills, should possess adhesiveness and firmness duly balanced one against the other, and, this, in fact, constitutes the *plastic condition*.

Such, then, are the conditions to be fulfilled in forming a good pill-mass, and with a view to the realization of which, the selection of excipients should be made.

But there are other considerations besides those above alluded to, which ought to influence the selection of excipients. Those substances only should be used as excipients which, fulfilling the specified requirements in other respects, will not be incompatible with any of the

ingredients of the pills ; will modify as little as possible their action, either by causing them to become hard, or in any other way ; and will not unnecessarily or inconveniently increase their size.

Powdered gum, either gum Arabic, or more frequently gum tragacanth, is often employed as an excipient, without discrimination, whenever increased tenacity is required in the pill-mass, or there is a superabundance of moisture in the prescribed ingredients. This practice of constantly adding gum is very objectionable, as it often causes the pills to become so hard that their operation is materially modified. Pills prepared in this way will sometimes pass through the intestines without being dissolved, producing, of course, little or no action. There are many cases in which the use of gum is justifiable, and cannot be well avoided, but the indiscriminate use of it, especially of tragacanth, cannot be too strongly condemned.

The physician frequently names, in the prescription, some particular excipient, which is directed to be used. Whenever this is done, the instructions of the prescriber should be carried out if practicable. It is not always, however, that this is practicable, and then the dispenser must follow his own judgment. It would be much better that the selection of excipients in these cases should be always left to those who dispense the medicines, as the prescriber rarely possesses the practical knowledge requisite to enable him to determine what kind of excipient is required. We frequently find two or three soft extracts, which when combined are too soft to admit of being properly made into pills, ordered to be mixed with mucilage or syrup *quantum sufficit*. In this case, although the dispenser cannot act up to the letter, yet he may carry out the spirit of the instructions, by using gum or sugar.

A few instances will now be specified in illustration of the foregoing principles, and with the view of more fully explaining the mode of proceeding in the preparation of pills. The principal substances which enter into the composition of pills will here be divided into classes which will be considered separately.

Rhubarb may be taken as the type of a class of substances frequently administered in the form of pill. *Jalap*, *ipccacuanha*, *ginger*, *conium*, *digitalis*, and other vegetable powders belong to this class. Now, taking these substances as a class, syrup is perhaps the best excipient to use for giving them the pilular form. With some of these powders, the use of an excipient that possesses and can impart adhesiveness is necessary ; and with all of them the presence of sugar is beneficial in preserving the vegetable principles from decomposition,

and preventing the pills from becoming very hard. Simple syrup is commonly used as the excipient, but there is an advantage in the substitution of uncrystallizable for the crystalline sugar which the simple syrup contains; treacle, therefore, is sometimes employed with advantage. If it be desired to deprive the treacle of its peculiar taste and smell, and of some of its colour, this may be done by diluting it with three or four times its weight of water, filtering the solution through a bed of animal charcoal, and finally evaporating it to the required consistence. Powdered conium, and other powders of this kind, retain their properties unimpaired for a great length of time when made into pills with a syrup of uncrystallizable sugar.

There are cases, however, in which the use of syrup with some of the powders alluded to is subject to inconvenience. Thus, when rhubarb or jalap is made into pills, it is often desirable to have as large a quantity as possible of the active ingredients in each pill. From three to five grains of the powder are frequently prescribed in a pill, and in such case it is desirable to use an excipient that will add as little as possible to the bulk. If syrup be used as the excipient for rhubarb, it will be found that a drachm of the powder will require a fluid-drachm of syrup; and this would make pills of four or five grains of rhubarb inconveniently large. Where it is important to add as little as possible to the bulk of the pill, water may be used as the excipient for rhubarb. It does not form so plastic a mass as syrup does; and, moreover, the pills, if long kept, become very hard, but the size of the pills will be less than would be the case if syrup were used. Spirit, especially rectified spirit, does not answer so well as water.

In making rhubarb into pills with syrup, the whole of the syrup required for forming the mass should be added at once. A drachm of powdered rhubarb requires a fluid-drachm of syrup. If a portion of this quantity of syrup be first mixed with the rhubarb, a hard mass would be formed, not sufficiently plastic to admit of being made into pills, and which it would be found very difficult to incorporate with the further portion of syrup required. On adding the required quantity of syrup at once, the mass is formed without any difficulty. The mode of proceeding in this case is just the reverse of that which should be adopted when a hard elastic extract, such as some specimens of extract of rhubarb, has to be incorporated with a powder, such as calomel or ipecacuanha, through the intervention of a liquid excipient, such as syrup. Under such circumstances, the quantity of syrup required should be added very gradually. If the whole of the

syrup were put in at once, so as to make a very soft paste with the powder, the hard extract would slip about in this, and might perchance be projected out of the mortar in the attempt at effecting the incorporation of the ingredients. The quantity of syrup first added should be only sufficient to form a very stiff and tenacious paste with the powder, and this should be partly incorporated with the extract before adding more.

Jalap is sometimes made into pills with tincture of jalap, when it is desired to have as much of the active ingredient as possible in each pill. In this case the spirit, as a solvent of some of the adhesive constituents of the jalap, imparts some degree of tenacity to the mass. The ingredients, however, do not yield a very plastic mass, and to succeed well in forming the pills, it is desirable to add the full quantity of tincture required at once, to make the mass rather soft, and to roll out the pills as quickly as possible.

In making *rhubarb and ginger pills*, spirit and soap are sometimes used as excipients with advantage. ʒjss of rhubarb, ʒj of essence of ginger, and ʒj of castile soap, will form a mass which may be divided into twenty-four pills, the size of which will not be inconveniently large. If strong essence of ginger, made as described at page 274, be employed, each pill will contain the active matter of fully two grains of ginger. The soap should be first rubbed with the essence, the rhubarb added, and the mixture allowed to stand until, by the evaporation of part of the spirit, it has acquired a good pilular consistence.

Aloes may be taken as the type of the next class of substances to be noticed. The *resinous extracts*, *resins*, and *gum-resins*, will come into the same class. Soap, mucilage, proof spirit, and alkaline solutions will be found to be suitable excipients in these cases. *Aloes* forms an excellent pill-mass with a few drops of compound decoction of aloes, the efficacy of which probably depends upon the presence of the alkali. The *gum-resins* will assume a good pilular consistence on pounding them with a little carbonate of potash without any other addition. The *resins* sometimes require a little spirit, but unless there be other solid ingredients present which are insoluble in the spirit, the pills thus made will often lose their shape. In such case soap should be substituted for spirit. Thus, the *aloes and mastic dinner pills*, when spirit is used in making them, inevitably lose their globular form, but this will not occur if soap and a little water be employed as the excipients. ʒvj of aloes, ʒij of mastic, ʒss of soap, and fʒss of water, mixed in an iron mortar previously made hot, will afford a good plastic mass while warm, and if rolled out while in this state, the pills may

be kept in quantity without losing their form. They may also be made with tolerable success with mucilage.

The volatile oils and *oleo-resins* constitute a class of substances which are occasionally made into pills, and in such case require peculiar excipients. Balsam of copaiba may be taken as a type of this class. Magnesia is the excipient most generally applicable. The copaiba balsam will generally assume a pilular consistence when mixed with an equal weight of carbonate of magnesia, and this is the best method of solidifying it, when the pills are required for immediate use. If the balsam should contain an unusually large proportion of essential oil, it may require more of the excipient, or it may be found convenient to dissolve a little white wax in the balsam previously to the addition of the magnesia. Sometimes the balsam is solidified by the addition of white wax alone. When sufficient time can be taken for the purpose, a very small quantity of calcined magnesia may be made to solidify balsam of copaiba or any of the fluid turpentine. One part of recently calcined magnesia, added to sixteen parts of balsam of copaiba, or true Venice turpentine, and allowed to stand for a week or two, will become solid and fit to form into pills. The mixture should be exposed to a gentle heat for about an hour, and should subsequently be stirred from time to time until it becomes solid. In this case, as in that previously alluded to, it must be observed that some specimens of copaiba, which are very rich in volatile oil, do not completely solidify without the addition of wax or of a portion of turpentine, such as Bordeaux turpentine. The peculiar action of the magnesia consists in the formation of a soap with the acid resins of the copaiba or turpentine, and this soap absorbs the volatile oil, which is the other constituent of the oleo-resin. Quick lime might be substituted for magnesia, and in some cases has been found to answer better.

Certain *volatile oils*, without any other active ingredients, are sometimes prescribed in the form of pill. Thus, *oil of pimento*, *cloves*, *peppermint*, &c., have been ordered to the extent of three or four drops in each pill, the selection of an appropriate excipient being left to the dispenser. The best excipients to use in such cases are soap and magnesia.

Calomel will form the type of a class of powders requiring an excipient which possesses and can impart adhesiveness. *Emetic tartar*, *antimonial powder*, and many other substances of this kind will come into the same class. Conserve of hips is a very useful excipient for this class of substances, at least for those of them which are not de-

composed by the vegetable acid contained in the conserve. It answers very well for making calomel pills, the pills retaining a soft consistence for a great length of time. In some cases crumb of bread, treacle, or extract of liquorice, may be substituted for it. Pills made with crumb of bread, however, become very hard after being kept for some time. Castor oil is an excellent excipient for the *compound calomel pills* of the Pharmacopœia. The mass, when made with this excipient, will retain a uniformly good consistence, which is not the case when treacle is used.

Crumb of bread is frequently employed as the excipient for *creasote*, and for some active agents, as croton oil and nitrate of silver, which are administered in very small doses.

The effect, in some cases, of a judiciously selected excipient is quite surprising, and the pharmaceutical student would find that the subject offers an interesting field for further experiment. When it is found that a substance so apparently ill adapted for making into pills as a liquid oleo-resin, may be rendered fit for that purpose by the addition of a very small quantity of magnesia or lime, and that fatty substances, such as mercurial ointment, will assume a pilular consistence on the addition of a little phosphate of lime, he may hope to find equally simple means for subjecting other apparently intractable substances to the required purpose.

In all cases it is very important that the whole of the ingredients of the pill-mass should be perfectly mixed and incorporated. When small quantities of active medicines form part of the ingredients, the precaution already alluded to in reference to the preparation of powders should be observed, that is, that such substances should be placed on the top of other less active ingredients, and well mixed with them.

[The mercurial blue mass requires some notice, though such notice is hardly in place in this chapter. Owing to the high price of mercury, and the competition of manufacturers, many instances of adulteration have occurred, either by substituting some heavy substance, as blue slate for the larger part of the mercury, or by simply increasing the amount of conserve at the expense of that of the metal. The most convenient means of ascertaining the percentage of mercury in a specimen of blue mass, is by means of the arrangement, fig. 474, which has been copied from the American Journal of Pharmacy, vol. xvii. p. 311. Thirty grains of the mass, mixed with ten of iron filings, is placed in the bulb at *c*; the tube (*a*) passes through the cork of the vial (*b*), and plunges just below the surface of the alco-

hol contained in it. The flame of a spirit lamp is applied to the bulb until it becomes red-hot, and all the mercury has been driven over into the tube or the vial. It is well to urge the flame with a blowpipe towards the last, so as to insure the complete volatilization of the metal. The alcohol rises in the tube by the contraction of the atmosphere of the bulb, and should be chased back and suffered to rise again several times, until all of the globules have been washed down into the vial. The alcohol dissolves the empyreumatic oil, and

is decanted from the mercury, which is then washed with pure alcohol, collected on a filter, and dried.

Theoretically it should weigh ten grains, but if $9\frac{1}{2}$ or $9\frac{3}{4}$ grains, it may be inferred that the mass examined is correctly constituted.

Various machines have been invented from time to time for simplifying the manufacture of blue mass. One of the more recent of these is that of J. W. W. Gordon, of Baltimore, at fig. 475, which is particularly described, and the result of an examination of its merits, by a committee of the Philadelphia College of Pharmacy, recorded, in vol. xxi. p. 6, of the American Journal of Pharmacy. The ingredients for the mass are put into the cylinder

(*c*), and are operated upon by the knives, *n* and *m*, as placed in connexion with the guide-plate at *d* *k*, and which is moved by the crank (*g*) and the connecting rod (*f*).

Fig. 474.

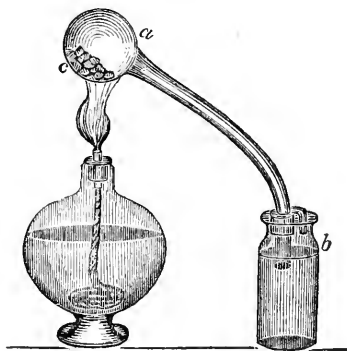
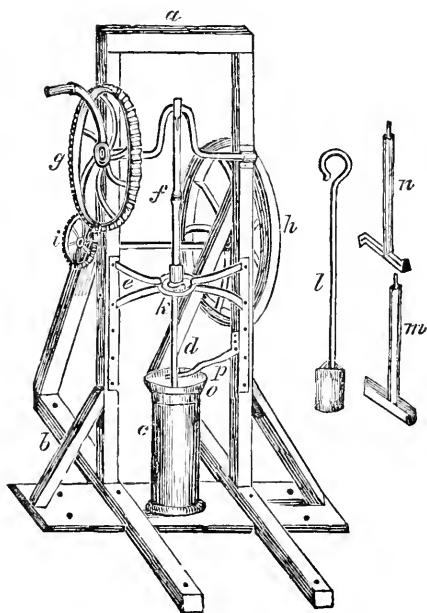


Fig. 475.



The knives have edges above and below, and hence act as they rise and fall; and by an arrangement in the guide-plate, the knife is made to change its position with reference to the cylinder at every turn of the crank. This machine, by the power of one man, is calculated to make thirty pounds of blue mass in a day, and the quality of the product is good. For further particulars relating to this apparatus, the reader is referred to the authority above mentioned.

Another machine has more recently been brought to notice, but as yet no published account of it has been given. It consists of a strong bar of iron, bent in a conical spiral form, in such a manner that the two ends of the bar are in the axis of the cone. This spiral bar is caused to revolve in a funnel-shaped iron vessel, by means of a cog attached to its upper end. The ingredients to be acted on are placed in the cavity of this vessel, and the friction caused by the revolution of the spiral bar is the means for commixing them. The tendency of the revolving spiral bar is to force the mass into the bottom of the cone; but as it cannot remain there, it is forced to rise in the centre of the spiral, and descend again in course. This machine is said to be very efficient. That of Gordon's, however, when worked by steam power, produces an excellent dark-coloured mass, in all respects equal to that made by careful and prolonged trituration.—W. P.]

The pill-mass being formed, the next operation consists in dividing it into pills. This is effected by means of the pill-machine. Little need be said with reference to the use of this instrument. In most cases the formation of the pills is a simple and easy process, yet cases will sometimes occur, in which, after exercising all his skill in making the pill-mass, the dispenser will find it difficult to roll the mass into pills, in consequence of its tendency to crumble. This is the case with jalap pills made with tincture of jalap, and more especially with the pills of volatile oil, magnesia, and soap. When the mass has a great tendency to crumble, the processes of forming the mass and of rolling out the pills, should be performed as quickly as possible. The mass should be made rather soft, and then immediately rolled and cut into pills, with a quick and dexterous hand, avoiding the application of much pressure in the process of rolling.

The pill-finisher, fig. 476, is a useful appendage to the pill-machine. It is used for finishing off the pills after they have been cut in the machine, obviating the necessity for rolling them separately in the fingers. The finisher consists of a circular disk of wood, of which

fig. 476 is a section ; with a projecting rim on the lower surface, and a broad flat knob on the top, which serves as a handle. It may be made of pear-tree, or any other hard wood ; it should be about three inches in diameter, and the depth of the rim should be rather less than the diameter of a pill. In fact, there should be two or three of these finishers with rims made to suit different-sized pills.

Fig. 476.



THE PILL-FINISHER.

In using the finisher, the pills are placed on a tray, or on the platform of the machine, with some of the powder used for covering them, and the finisher, held by the knob, being placed over them, is moved in a circular direction with increasing velocity, while a very slight pressure is applied.

Several substances are used for covering pills, such as *magnesia*, *starch*, *liquorice powder*, *lycopodium*, *gold and silver leaf*, *gelatine*, and a mixture of *gum and sugar*. The application of these substances to the surfaces of pills is intended to prevent their sticking to each other or to the box, and also to prevent their being tasted during the act of deglutition.

Magnesia is very commonly used for covering pills. As a light absorbent powder it answers the required purpose very well, yet there are some cases in which its use is not free from objection. Thus, for instance, if calomel pills be covered with magnesia, decomposition will, after some time, occur, the mercury being reduced, or oxide formed together with muriate of magnesia. Calomel pills that are kept ready made should never, therefore, be covered with magnesia ; powdered starch might be used in this case.

Liquorice-powder is sometimes employed in preference to magnesia for covering pills, its sweet taste being considered advantageous in masking that of the other ingredients of the pills. There is, however, a very serious objection to the indiscriminate use of this powder, which arises from the fact that, with some persons, it occasions an irritation of the fauces, which deprives them of the power of swallowing pills which are thus covered.

Lycopodium is but little used for covering pills in this country. It is extensively employed on the continent, and it forms, undoubtedly, the most suitable powder for the purpose. It is a light powder, the particles of which readily adhere to the moist surfaces of pills, without becoming themselves moist. It is also free from taste, and has no tendency to cause or to undergo decomposition. When lycopodium

is used, it should be applied to the pills on the machine or in the finisher, and none of the powder excepting that which adheres to the surfaces of the pills should be put into the box. Pills thus prepared have a much cleaner and more finished appearance than those to which a quantity of unattached powder is added, as is generally the case when magnesia or liquorice-powder is used.

The application of *gold* or *silver leaf* to the surface of pills is a very ancient method of covering them. The gilded or silvered pill is still occasionally administered, but much less frequently than formerly. The method of gilding pills is very simple. The pills are first rolled and cut on the machine, the mass having been previously made rather stiff, and little or no powder of any kind used on the pill-machine. Two or three sheets of gold-leaf are now put into a suitable box. A turned box of a globular form, consisting of two hemispheres fitting together, and the capacity of which is about two ounces, is usually employed; but, in the absence of this, a two ounce chip-box will answer the purpose. The metallic leaves having been loosely put into the box, the fore-finger and thumb of each hand of the operator is moistened with thin mucilage of gum-acacia, and two pills being rolled in the fingers so as to moisten their surfaces and render them adhesive, these are dropped into the box; others of the pills are subsequently treated in the same way, taking care that none of the pills thus introduced shall come into contact with the ungilded surfaces of those previously put in. When six or eight pills have been introduced into the box, the lid is put on, and a circular motion is given to the box, by which the gilding is effected. The process is repeated in this way until the whole number of pills required have received the metallic coating.

The same mode of operating is adopted when silver leaf is used.

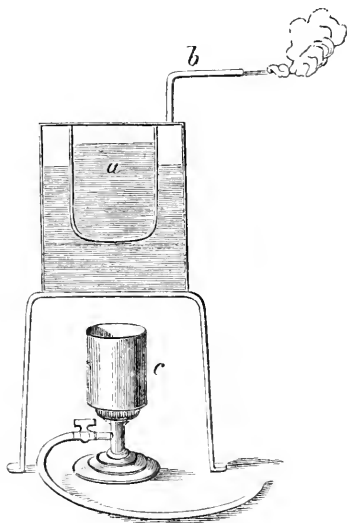
Of all the methods adopted for covering pills this is the most objectionable. Gilded pills have often been found to pass through the entire alimentary canal without undergoing any alteration, being completely protected by their metallic covering.

The covering of pills with gelatin is the most elegant and efficient method of fulfilling the objects contemplated in the processes now under notice. A pill when thus covered, has a clean, shining surface, which is dry, hard, and not at all sticky. No powder is, therefore, required in addition to the gelatin. The ingredients of the pill being enclosed in a gelatinous case, are preserved from the action of the air, and, to a certain extent, are prevented from undergoing volatilization; moreover, the pill itself may be swallowed without perceiving taste or smell.

The following is the method of covering pills with gelatin:—

In the first place, a solution of gelatin is prepared, consisting of one part of gelatin and two parts of water. This solution may be made in a little water-bath such as that represented in fig. 477. The gelatinous mixture is put into the vessel (*a*), where it is surrounded by hot water contained in the outer vessel, and the heat is maintained by the gas-lamp (*c*), while the steam escapes through the tube (*b*).

Fig. 477.



The pills are now made as in the preceding case, without using any powder, or if powder be used on the machine, it must be subsequently wiped off the pills.

A number of straight, pointed wires are in the next place provided, each of which should be about four or five inches long. The black hair-pins used by ladies, when made straight, answer the purpose very well. A large pin-cushion, or a dish filled with sand, in which the wires can be fixed erect, will also be required.

Each pill is to be stuck on the point of one of the wires, and when they are all mounted in this way, the pills are dipped, one at a time, into the solution of gelatin, so as to be completely covered, and the wires are then stuck into the pin-cushion or sand with the coated pills at the top, as is shown in fig. 478. They are left in this position until

Fig. 478.

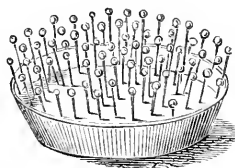
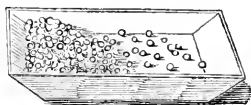


Fig. 479.



COATING PILLS WITH GELATIN.

the gelatin has become firm, which will be in about ten minutes or a quarter of an hour, when the pills are removed from the wires and put into a tray, fig. 479, where they are left to dry.

It will generally happen that in dipping the pills, a portion of the wires will become covered with gelatin, and this, on removing the pills will remain attached to them, forming little projecting tubes, which should be cut off with a pair of scissors. If it be desired to make the coating of gelatin perfect, the hole at which the wire has entered the pill must be touched with the point of a camel's hair pencil previously dipped into the solution of gelatin.

Gum and sugar are sometimes used for covering pills. The pills are put into a hemispherical metallic pan, which is slightly warmed, and a small quantity of the solution of one part of gum in two parts of water is added, so as to moisten the surface of the pills. Some powdered sugar is then sprinkled over them, and by moving the pan they are thus covered with a coating of sugar. They are subsequently placed on a sieve and exposed in a warm room until they become dry. If a thicker coating be required, the process is repeated.

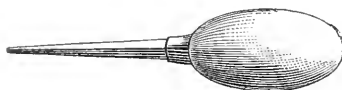
CAPSULES.

Some nauseous medicines, especially *copaiba*, are administered in capsules, which are made either of a mixture of gelatin with sugar, and sometimes with gum, or of prepared gut-skin.

Gelatin Capsules.—These are small egg-shaped vessels, into which a liquid or semi-liquid medicine is introduced through a small aperture at one end, which aperture is subsequently sealed.

In making the capsules, a number of moulds, consisting of polished iron bulbs, are provided, of which fig. 480 is the real size. These bulbs are turned at the lathe, so as to be perfectly smooth, symmetrical, and uniform; and each bulb is fixed to one end of a wooden rod, six or eight inches long, while the other

Fig. 430.



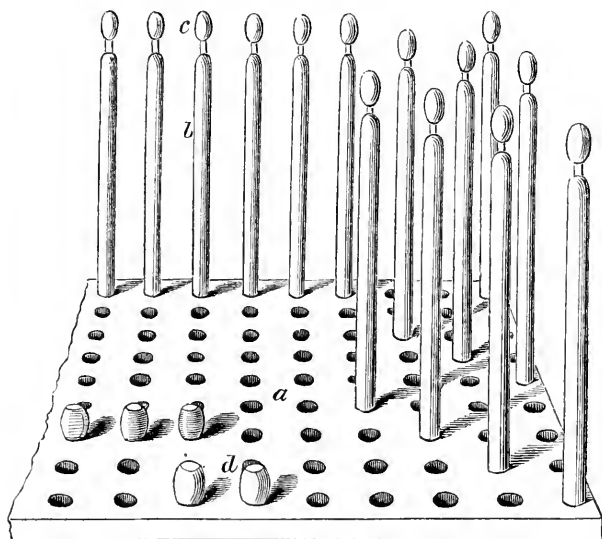
THE CAPSULE MOULD.

end of the rod fits loosely into a round hole in a board, as shown at *a b c*, fig. 481. The board (*a*) has a great number of holes perforated in it, which are intended to receive either the moulds (*b c*), or the capsules (*d*).

A solution of six parts of gelatin and one part of sugar, in twelve parts of water, is made in the water-bath, fig. 477, in which it is kept constantly hot and fluid.

The moulds are first wiped with a cloth slightly moistened with oil; they are then dipped into a solution of gelatin, so that the bulbs may be completely covered; and on taking them out, the excess of solution is allowed to run off until they cease to drip, when they are fixed on the board (a) with the coated bulbs upwards, as represented in the

Fig. 481.



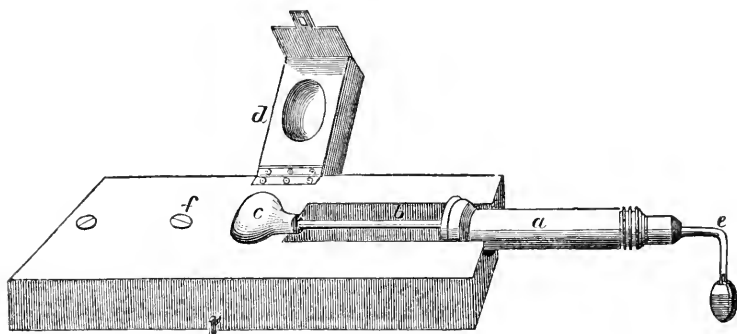
PREPARATION OF CAPSULES.

drawing. This operation is continued until a great number of moulds have been dipped, by which time the gelatinous coating on those first dipped will have become cold and firm. The separation of the capsules from the moulds may now be commenced. A knife is passed round the shank of the mould, close to the bulb, so as to separate the gelatinous covering from that which adheres to the handle, and the capsule is then pulled off by a dexterous application of the thumb and two fore-fingers of one hand of the operator, while the handle of the mould is held in the other hand. If the gelatinous solution has been well prepared, and is in good condition, the orifice of the capsule will expand so as to pass over the thickest part of the bulb without breaking, and will resume its original size when it has slipped off. The gelatinous mixture becomes more elastic after it has been kept melted for some time: the addition of a little gum also increases its elastic property, but gum makes the capsule more speedily soluble in the contents of the stomach, which is sometimes objected to. On removing

the capsules from the moulds, they are placed on a tray, and exposed in a warm room until they become perfectly dry.

The next operation consists in filling the capsules with the liquid they are intended to receive. In doing this, the dry capsules are placed with their mouths upwards on the perforated board, as shown at *d*, fig. 481. The capsules are conveniently filled by means of a syringe, as represented in fig. 482. The syringe (*a*) being charged with the liquid, is placed in a groove (*b*), cut for this purpose in a

Fig. 482.



FILLING CAPSULES.

board (*f*), which is secured on the top of a table, while the piston of the syringe is fixed at *c*, by the bar (*d*) which is fastened down over it. There is a very slender nozzle to the syringe, which is bent as shown at *e*. The operator places one of the capsules over the point of the nozzle, while he gently presses the syringe against its piston, thus forcing the required quantity of liquid into the capsule. On removing the capsule after it has been thus filled, it is desirable to avoid leaving any of the oil on the edges of the orifice, as this would interfere with the subsequent sealing process. If the capsule were removed from the nozzle while a drop remained attached there, the mouth of the capsule would almost inevitably catch the drop, but this is obviated by slightly drawing the syringe forward, by which the suspended drop is sucked into the tube, before removing the capsule. The liquid introduced into each capsule should be equal to about three-fourths of its capacity; if more than this be introduced, it would be difficult to prevent leakage, which would be caused by atmospheric changes, for increase of temperature occasions expansion of the liquid, and at the same time contraction of the containing vessel.

[The manufacturers of gelatin capsules in this country, adopt a

more labour-saving method of making them than that indicated in the text. Fifty of the moulds, made of ivory and dipped in hot oil until saturated, are attached to a circular flat block, just as the bristles are in a brush; a handle is placed on the other side of the block, and the whole fifty are dipped in the gelatin at one operation. It requires some practice in manœuvring the blocks to keep the moulds equally covered. After dipping, and the excess has run off from the moulds, the block is turned up and down several times, so that the gelatin may be evenly distributed over the surface of the moulds; as soon as the capsules have become sufficiently indurated, the moulds are detached one at a time and the capsule removed, just as has been stated in the text.

An advantage will be found in having the cylinder of the syringe, fig. 482, to be stationary, and the piston-rod to work in a screw, so that it can be controlled with accuracy.—W. P.]

The capsules being all filled and restored to their position on the board (*d*, fig. 481), the sealing process is commenced. A small camel's hair pencil is dipped into the gelatinous mixture, which when used for this purpose should always contain a portion of gum, and the mouth of each capsule is touched, so as to leave a sufficient quantity of the gelatin to seal it. When they have all been thus sealed, some of the gelatinous mixture is thinned with water, and the top of each capsule is dipped into this solution, and then again placed, with the sealed end upwards, on the board. By this last operation a little cap is formed over the mouth of the capsule, which renders the sealing more secure.

Finally, when dry, the sealed capsules are put on to a cloth slightly moistened with oil, and rubbed, so as to give them a clean and polished appearance.

Membrane capsules.—A patent has been taken out for the manufacture of capsules from animal membrane, which is purified and prepared for this purpose. The prepared and moist membrane is stretched over a mould so as to give it the form of a conical bag. Into this, when dry, the liquid is introduced; the mouth of the bag is then tied with silk, and sealed with a little gelatinous varnish.

These capsules possess some advantages over those made of gelatin. In proportion to their external size, they hold more liquid than the gelatin capsules do, in consequence of the membrane of which they are made being very thin. They are also very flexible and compressible, which is a great recommendation with some patients, who are fearful of attempting to swallow a hard, rigid body, of the size of a capsule. Moreover, the membrane being less rapidly dissolved than

the gelatin mixture is, by the juices of the stomach, the capsules made of the former do not discharge their contents so soon as those made of the latter, and eructations are, therefore, less likely to ensue.

GARGLES—ENEMAS—INJECTIONS.

These forms of medicine resemble the *mixture* in their general characters, and the mode of preparing them is similar. Being intended for local application, and not to be introduced into the stomach, the labels attached to them should clearly indicate this distinction. The old method of administering enemata with a pipe and bag is now entirely superseded by the use of the syringe.

LOTIONS—LINIMENTS—EMBROICATIONS.

These are medicines, of a more or less fluid character, which are intended for external application. *The lotion*, as the name implies, is a wash, and it may be for any part of the body. Lotions for the eyes are sometimes called *Collyriums*. The terms *liniment* and *embrocation* are frequently used synonymously; the former, however, being derived from *lino*, to besmear, is applicable to something thick as well as fluid, while the latter, being derived from ἐμβρέχω, to moisten or sprinkle, applies exclusively to a liquid.

It has been proposed that liquid medicines intended for external use should be always dispensed in bottles made of blue glass, to distinguish them from those designed for internal administration, the latter being dispensed in white glass. If such a practice were universally adopted, it would certainly be a good method of guarding against accidents which sometimes occur in consequence of an embrocation being mistaken for a draught. It is questionable, however, whether the partial adoption of the practice would be beneficial; but it is very important, at all events, that there should be some prominent indication, in the form of label or otherwise, to distinguish external applications from medicines to be administered through the stomach.

OINTMENTS.

Under the general denomination of *Ointments* are included medicines intended for external application, the principal basis of which

consists of some kind of grease, which is either naturally, or from the admixture of other substances, in the condition of a soft solid. Ointments to which a firm consistence has been imparted by the addition of wax are sometimes called *Cerates*.

Salts and other solid substances are frequently ordered to be extemporaneously mixed with ointments, and the principal art connected with the dispensing of this form of medicine, consists in the adoption of the best methods of effecting the most intimate admixture of such ingredients, or of any others which may not readily combine.

Ointments are mixed either in a Wedgwood's mortar or on a marble slab. The mortar should always be used when salts or other substances, which require to be previously powdered, form part of the ingredients. The presence of hard particles, giving a gritty character to the ointment, is very objectionable, and would indicate want of skill, or of careful attention, in the dispenser. The mere admixture of two or more ointments may be effected by rubbing them on the slab with a spatula.

Some salts, such as iodide of potassium, are with difficulty reduced to fine powder even in a mortar, and in these cases it is desirable, when practicable, to add some liquid which shall act as a solvent before the addition of the unctuous constituents of the ointment. Thus, iodide of potassium, if it be first dissolved by a few drops of water, before mixing it with the grease, will form a perfectly smooth ointment, which it would be difficult otherwise to obtain.

Ointments are dispensed in covered gallipots, and it is customary to put a piece of waxed paper [or tin foil] over the top of the pot, beneath the cover, so as to prevent the latter from becoming smeared with the grease.

SUPPOSITORIES.

The suppository is a form of medicine now very rarely adopted. It is intended for the administration of medicinal agents to the rectum. The ingredients are made into a paste, which is usually rolled into a conical form, like a pastil. Soft soap or grease is generally used as the excipients for giving the required consistence to suppositories.

CATAPLASMS.

The cataplasm or poultice generally consists of a pulpy substance, capable of absorbing much moisture, which is applied to various parts

of the body in a moist state. Poultices are almost always prepared by the nurse: their action usually depends upon the liquids with which they are moistened, or the heat which the mass retains. The solid ingredients of the poultice being useful only for holding a large quantity of liquid, which is thus applied continuously to a diseased part, it has been proposed to substitute an absorbent fabric, called the *spongio-piline*, which is made expressly for the purpose. This is a kind of thick cloth, composed in great measure of sponge. Over one of its surfaces there is a thin coating of some water-proof material, which prevents evaporation, when the other side, previously wetted, is applied to the skin.

MOXAS.

[The term *moxa* was formerly applied only to small conical masses of combustible fibrous matter derived from the leaves of *Artemesia Chinensis*, and which were used for producing an eschar, by igniting the summit of the cone, the base being applied to the skin in the region of the diseased part, and allowing the combustion to approximate near or quite to the skin, according to the effect it might be desired to produce. Moxas are now made from other materials. The pith of the common sunflower, *Helianthus annuus*, has been used; cotton impregnated with a solution of nitre, dried and made into a uniform cylindrical roll, enclosed in paper, has been employed; and loose cotton cloth, impregnated with solutions of chromate or chlorate of potassa, dried, and formed into cylindrical rolls, is perhaps equal to any other form. The slow uniform combustion of a moxa is its most important quality; and as its combustion is supported chiefly by the oxygen of the acids of the salts used, the chief art in this preparation consists in equally impregnating the fibrous matter used, and constructing the roll of equal density throughout.—W. P.]

PLASTERS.

Plasters are solid and tenacious compounds, intended for external application. They frequently contain the oleate and margarate of oxide of lead as a principal basis; wax, resin, solid fats, and essential oils, are also among the ingredients which often enter into their composition. At the usual temperature of the human body they should be flexible, and more or less adhesive, but not so soft as to run.

Plasters are used, *mechanically*, for affording support or pressure to the parts to which they are applied, for binding up wounds, and for preventing atmospheric contact; and, *medicinally*, as stimulant, epispastic, discutient, or anodyne applications.

The spreading of plasters is one of the operations connected with the dispensing of medicines, in which the pharmacist has occasion to exercise more acquired skill than is involved in many other departments of his art.

Plasters are generally spread on leather, calico, or linen. Sometimes, however, silk, animal membrane, and even paper, are used. Those spread on leather will be first noticed.

When a plaster is ordered by the prescription of a medical man, in addition to the ingredients of which it is to be composed, the size and form are frequently, but not always, indicated. In some cases, the part is named to which the plaster is to be applied, and the determination of the form and size is left to the judgment of the dispenser. There are certain forms of plaster which are generally adopted for application to particular parts of the body, and in the absence of specific instructions, the dispenser should comply with the usual and recognised practice in this respect. Thus, fig. 483 represents the form of plaster usually applied to the chest; fig. 484 is the form for application between the shoulders; fig. 486 for the small of the back, or for parts not indicating any other particular form; fig. 487 is the

Fig. 483.

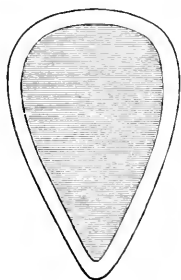


Fig. 484.

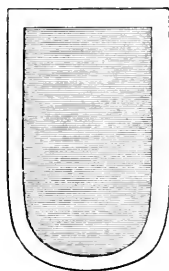
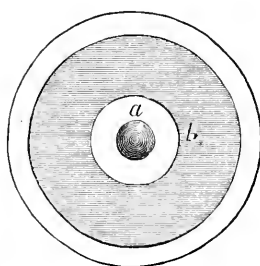


Fig. 485.



form usually adopted for the side; fig. 485, for applying pressure to the navel of children; and figs. 488 and 489, for applying behind the ears, the former being for the left, and the latter for the right ear. It will, of course, be understood that the figures represent only the forms, and not the relative sizes, of the plasters. Some of these forms, especially figs. 483 and 484, are so frequently employed, that

it is found convenient to keep the pieces of leather on which they are spread cut ready for use. By adopting this practice, a skin may be

Fig. 486.

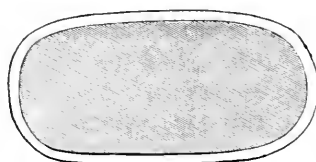


Fig. 487.

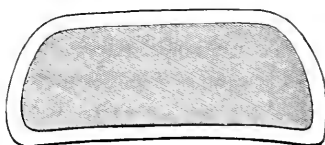


Fig. 488.

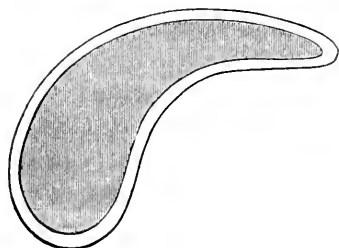
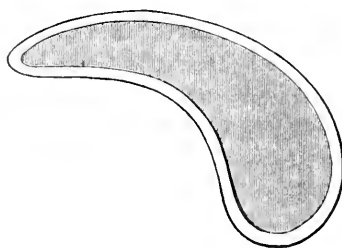


Fig. 489.



cut up to much greater advantage than it would be if each piece were cut out when required. Patterns of the forms and sizes most frequently required, made of thick pasteboard, should be kept for marking the skins with a pencil previously to cutting them. There might be two or three sizes of fig. 483; two of fig. 484; and several of fig. 486. These pieces of leather, when cut, should be kept in a drawer, properly divided for the reception of each size separately, the pasteboard pattern being put at the bottom, and a thick piece of flat sheet lead at the top, the latter serving as a weight to press the leathers, and keep them smooth.

The plaster spatula, fig. 490, is employed for spreading plasters, and the facility with which the operation is performed will greatly depend upon the selection of this instrument. There should be several spatulas kept, varying in size and form, so that the dispenser may choose one suitable for its intended application. The spatula serves as the medium through which heat is conveyed to the plaster for the purpose of melting it, and it is subsequently used for spreading the melted mass smoothly over the surface of the leather. The heat of the spatula passes off during the operation, partly by conduction, to the plaster, and partly by radiation, into the air; yet it is necessary that it should retain a certain degree of heat until the process is com-

pleted. As the temperature of the spatula when its use is commenced must be always nearly the same, the different amounts of heat required for spreading small and large plasters can only be provided by varying the size of the blade of the instrument.

Fig. 490.

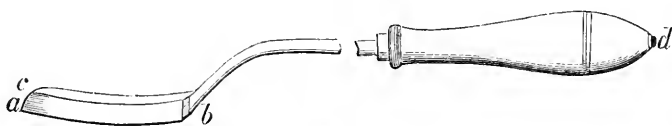
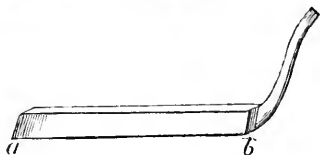


Fig. 491.



PLASTER SPATULAS.

It is desirable that the spatula should not be larger than is necessary, in order to provide a sufficient supply of heat, especially in spreading small plasters and those having sharp angles, such as fig. 483, as it would be difficult with a large spatula to avoid soiling the margins. For small plasters, it will be found advantageous to use a spatula, the lower surface of the blade of which is slightly curved, as represented in fig. 490. In using this kind of spatula, the end (*a*) of the blade may be applied to the surface of the plaster without bringing the heel of the instrument (*b*) into contact with any part of it. Spatulas used for spreading large plasters, such as those applied to the small of the back, should have flat blades, as shown in fig. 491, for it would be difficult with a curved blade to make the surface of a large plaster sufficiently smooth. In all cases the blades should be thick in the direction *a c*, fig. 490. It is also very important that the iron shank of the spatula should pass through the wooden handle to the end *d*, and be secured there by a nut. If the handle is not thus secured, it will be constantly coming off, being loosened by the action of the heat.

The leather on which the plaster is to be spread being cut to the required shape and size, and a suitable spatula selected, the blade of the latter is made hot by putting it into the fire. A little experience will enable the dispenser, by holding the instrument within a few inches of his face, to determine when it has acquired sufficient heat. The heated iron is first rubbed on a mat to make it clean; it is now

ready for use, and should be promptly employed before it loses any material part of the store of heat which it holds, and which is intended to impart the required degree of fluidity or softness to the plaster, and to maintain this condition until its extension over the leather has been completed.

Ten or twelve sheets of paper are placed upon the counter, and the leather is laid on the top of these. The paper forms a bed of a due degree of elasticity, and which prevents the too rapid conduction of heat from the plaster while it is being spread. If the leather were laid directly on the counter, or with only one or two sheets of paper intervening, the heat of the liquefied plaster would be rapidly carried off by the cold surface of the polished wood.

Before commencing the melting of the plaster, the leather is smoothed out by passing the hot iron over it, and, in doing this, it is very necessary to be careful that the iron is not so hot as to cause the leather to shrivel up. If the spatula be in a fit state for melting the plaster, it will not injure the leather when applied to it.

If the material of which the plaster is composed be sufficiently adhesive to insure its remaining fixed to the part of the body to which it is applied, it is spread, without any previous preparation of the leather, to within about half an inch of the edge, leaving a margin of this width of uncovered leather; but plasters possessing little or no adhesiveness, ought to be surrounded by an adhesive margin, and in such case the margin must be prepared before spreading the plaster. There are two methods of preparing the adhesive margin: the adhesive plaster may be either spread entirely over the leather to the very edge, or it may be merely applied around the edge of the leather, so as to form a border of about an inch in width. The former of these methods should be adopted if the plaster, when exposed to the heat of the body, is liable to run through the leather, as is the case with the blistering plaster of the Pharmacopœia, for the substratum of adhesive plaster would tend to prevent such a result. In other cases it may be unnecessary to protect the leather, and even desirable to avoid increasing the thickness of the plaster by having two strata throughout.

When the adhesive plaster is merely spread on a border around the edge of the leather, it is customary to melt the plaster by applying the end of a roll of it to the hot iron, allowing it to drop as it liquefies on to the part of the leather to be covered, and subsequently to spread it with the spatula. In doing this the iron should be only just hot enough to melt the plaster, as otherwise the drops of hot melted

plaster would occasion permanent marks on the leather, which would disfigure its subsequent appearance.

When the adhesive plaster is extended over the whole of the leather, it should be allowed, as it liquefies from contact with the hot iron, to run on to a piece of strong paper, and transferred from thence to the leather.

The adhesive margin, if required, having been prepared as above directed, the spreading of the plaster may be proceeded with. The spatula, after being used for the preceding operation, will require to be heated again before it can be applied for melting another portion of plaster.

The melting of the plaster may be effected in the manner already described, by applying the hot iron to one end of a roll of plaster and allowing the liquefied portion to run on to a piece of strong paper, from whence it is subsequently transferred to the leather. If the leather has not been rendered adhesive, the paper on which the melted plaster is received should be placed upon it while the process of liquefaction is being conducted, so that whatever heat passes off by conduction, may be communicated to the leather and to the paper beneath it, and these being thus warmed, the subsequent cooling of the plaster, while it is being spread, will take place more slowly. Every available means by which the expenditure of heat can be economised should be put into requisition in spreading a plaster, especially if it be of large size. The careless or inexperienced operator will sometimes commit the twofold error of commencing the melting of the plaster by the application of a spatula heated to such a temperature that it causes a decomposition of some of the constituents of the plaster, and the evolution of acrid vapours, while at the same time, the means of economising heat are so imperfectly adopted, that the mass becomes hard and intractable before its extension over the leather has been completed.

When the blade of the spatula has expended so much of its heat in melting the plaster, that it is scarcely hot enough to melt any more, it will be in fit condition for spreading the melted mass. The method of effecting the extension can be properly acquired only by practical experience; it may be observed, however, that the plaster should not be spread out to its furthest intended limits until it has passed from the fluid or semifluid to the plastic condition. It is only while in this latter condition that it can receive with effect the last finishing touches of a skilful hand. When completed, the plaster should be of equal thickness in all parts; the surface should be even, but not

too glossy; and the edge should rise perpendicularly from the margin.

There are some special cases in which a mode of proceeding somewhat different from that previously described is required to be adopted, as for instance, in preparing the plaster, fig. 485, for applying pressure to the navel of a child. This plaster has a globular protuberance in its centre, which is surrounded, first, by a circle of uncovered leather (*a*), then by a broader circle (*b*) of adhesive plaster, and, finally, by a margin of uncovered leather. The globular protuberance is formed by cutting the end of a large vial cork, as shown in fig. 492, and fixing

Fig. 492.



this in the centre of the plaster. A piece of soft white glove-leather is stretched over the globular end (*a*) of the cork, and tied with fine string in the groove (*b*); the cork is then cut off at the dotted line (*c*). A piece of thin leather of the intended size of the plaster is, in the next place, spread with a thin coating of adhesive plaster, and the glove-leather with the cork attached, is laid over the adhesive surface of this, the cork being in the centre, and its globular part upwards, while a warm and

clean spatula is rubbed over the surface of the glove-leather, so as to make it adhere firmly to the plaster beneath. The broad adhesive circle (*b*) has now to be spread. A small piece of tissue-paper is placed over the globular protuberance in the centre to protect it from being soiled by the spatula. A piece of stiff writing-paper, of the size of the circle (*a*), is also placed over the part of the leather which is to be left uncovered by the plaster. These preparations having been made, the adhesive plaster is spread over the part *b*, with the curved spatula, fig. 490, in the manner already described.

[In spreading plasters containing gum-resins or extracts, if they are melted with the plaster-iron or spatula, it should be heated very moderately, else there will occur a separation of the ingredients, and an injury accrue to the more active, either by volatilizing a portion, or by decomposing them. When iodine plaster is ordered, without a special direction, lead plaster should not be used, because the iodine combines with the lead, forming iodide of lead, colours the plaster yellow, and loses all odour of the free iodine. The best vehicle is Burgundy pitch, admixed with a tenth of its weight of wax, which are melted in a porcelain capsule. The iodine, mixed with half its weight of iodide of potassium, is liquefied with a few drops of water, added to the melted plaster, and intimately mixed with it. The

spatula should be but moderately heated, to avoid loss of iodine.—W. P.]

In spreading blisters, the leather having received an adhesive surface, the blistering plaster is extended over it by the application of the thumb of the operator. The hot iron should not be applied at all, being quite unnecessary, and calculated to injure the plaster as regards its vesicating property. The thumb may be moistened with water to prevent the adhesion of the plaster to it.

[Blisters are sometimes spread on common adhesive plaster. When this material is used, an opening is cut in a piece of letter-paper of the shape and size of the surface to be blistered. This is pressed firmly and evenly on a piece of the plaster, so much larger than the opening as to leave a margin of half an inch or an inch, according to the size, so as to be held firmly by it. The cerate is then spread with a stiff spatula, and when smooth the paper is removed.

The importance of the action of blistering plasters is sometimes so great, that the pharmacist should take special means to insure their activity. He can do this by applying a thin layer of ethereal extract of cantharides with a camel's hair brush, and working it into the surface of the plaster with a spatula.—W. P.]

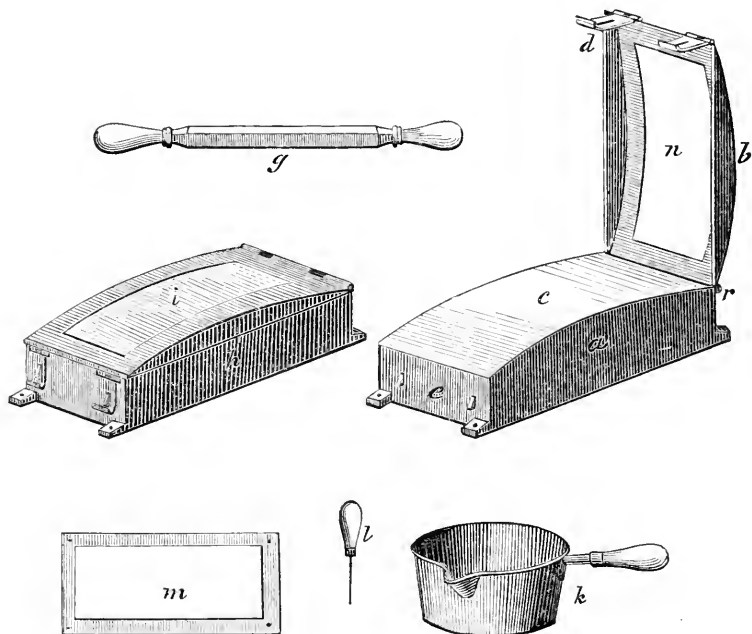
The margins of plasters are sometimes formed by placing over the leather, while the plaster is being spread, a piece of tin-plate or stiff paper, having an open space in the centre of the size and form of the intended plaster. This is taken off after spreading the plaster, and with it is removed any portion of plaster which has extended over it, leaving the margin untouched. Plasters thus prepared have, generally, a less finished appearance than those spread in the manner previously described, and, indeed, this method of operating is adopted only as an expedient to obviate the necessity for acquired skill and careful manipulation.

[In the United States, the preparation of spread plasters is a heavy item in some pharmaceutical establishments. They are put up in boxes of a dozen each, with tissue-paper between, and include several officinal and many empirical plasters. To furnish these at the prices they are sold would be hardly possible, were they spread by the usual means that have been noticed. For several years past an apparatus has been in use for this purpose, the construction of which has been carefully concealed, except from those immediately interested, or who might purchase the right of using the machine. It is a pleasure, therefore, to make a knowledge of the apparatus generally known through this medium, which I am enabled to do through the liberality

of my friend, John H. Ecky of this city, who has permitted me to figure the arrangement and describe the mode of its employment.

Fig. 493, *a c e*, represents a solid block of close-grained oak or beech-wood, about twelve inches long, eight inches wide, and three and a half inches high. The upper surface is rounded off towards either end, so as to present a gentle curve, and by means of projections at

Fig. 493.



APPARATUS FOR SPREADING PLASTERS.

the corners, the block may be securely fastened by screws to the working counter or a table. *b d* represents a tinned iron frame, the space *n* being of the size and shape of the plaster to be spread, and which is attached to the block by the hinge-joint *r*, in such a manner, that when the end *d* is brought down and fastened to the block by the hasps, it presses on the curved surface with some degree of force. *m* exhibits a pattern-frame for marking the leather into squares previously to cutting it out in pieces for spreading, and is made of brass or wood. It is good economy to mark a whole skin at once. In marking the leather, a pencil should be run around the inner as well as the outer edge of the pattern, so as to indicate where it is to be cut, as well as the extent of surface to be covered by the plaster. *g* represents the iron for spreading the plaster. It is a bar of cast-steel,

an inch square, perfectly smooth, the ends drawn out, and mounted with wooden handles. It should never be exposed to a heat great enough to injure the smoothness of the surface, and that derived from ordinary gas or alcohol lamps is appropriate. *k* is a copper vessel in which the plaster is liquefied, and *l* an awl for separating the plaster from the frame.

This apparatus is used in the following manner. The piece of skin, duly marked, is placed on the block at *c*, and the tin frame brought down and fastened over it, as at *i*, the operator observing that the pencil-mark on the skin, corresponds with the opening in the frame, so that the margin of the plaster shall be uniform. The melted plaster, which should be barely fused, so as not to penetrate, is then poured on the leather at *i*, in such quantity as the previous experience of the operator judges necessary for properly covering the surface exposed; he then takes the spreading-iron, *g*, which has been previously moderately heated, in his hands, holding it horizontally, and commencing at *i*, he presses the iron against the frame and moves it slowly towards either end, until the leather is uniformly covered with a smooth coating of the plaster, the excess of which is forced from the leather on to the tin frame. There is an advantage arising from having a ledge of tin a quarter of an inch high at either end, to prevent the plaster from running off the frame. As soon as the spreading is finished, and before the plaster chills, the operator takes the awl, *l*, in his right hand, presses it firmly but not too forcibly in one of the corners of the frame, against the leather, and draws it from corner to corner, completely around the opening, so as to sever the connexion of the plaster with the tin frame. The hasps are then unfastened, the frame raised up, and the plaster is completed. The whole operation of spreading a plaster only occupies two or three minutes after the apparatus is in working order.

The frame, *b d*, should press on the leather all around the opening, so as to insure that the melted plaster cannot insinuate itself between the under part of the frame and the leather, and thus render the marginal line irregular. If the iron is too cold, the surface of the plaster cannot be smoothed, if too hot it will cause it to penetrate the leather; the proper temperature will soon be learned by practice.

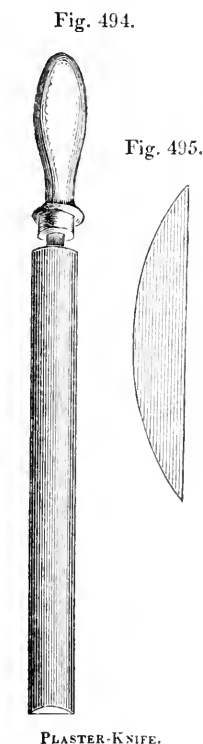
Mr. Eeky has suggested that an advantage will arise from having the frame, *b d*, made of sheet steel, like a saw-blade, without the lateral supports, which are necessary when tin is used. The elasticity of the steel would insure the firmness of the leather, which with the tin frame sometimes slips when the iron becomes too cool.

The opening in the frame can be made of any size, and its shape may be varied to meet any desired form that is required sufficiently often to justify it,—in fact, a set of frames may be at hand, which can readily be used with the same block, by withdrawing the hinge-pin, and replacing the one by the other.—W. P.]

Dr. Mohr gives the following description of the methods of spreading plasters on calico or linen.

The cloth on which the plaster is to be spread is cut into strips of about seven or eight inches in width, and three feet in length. These strips must be stretched out, so as to present an even surface for the spreading of the plaster. For effecting this, two flat pieces of wood, about fifteen or sixteen inches long, and of the width and thickness of a common lath, are provided. A row of sharp wire points are stuck into one edge of each of the laths for a space of about nine inches, leaving a few inches at each end without any. The points should project about the sixth of an inch above the surface of the

wood, and they may be at a distance of a quarter of an inch from each other; after being fixed they must be sharpened with a file. The ends of the laths, which are left free from points, are intended to serve as handles. The extreme ends of one of the strips of cloth are fixed to the laths by means of the points, a straight line across the strip, at each end, being found by drawing a thread. Two assistants lay hold of the laths by their ends or handles, and stretch the cloth by pulling in opposite directions. The plaster having been previously melted in a small copper dish, and stirred until it has partly cooled, so that it may not run through the cloth, is poured out in a uniform layer across one end of the strip, and extended evenly and equally by bringing the warm plaster-knife against it, and pressing it forward with a steady progression until it has reached the other end. If the plaster be not uniformly spread by one operation, as above described, the plaster-knife may be passed over it again to remove any inequalities.



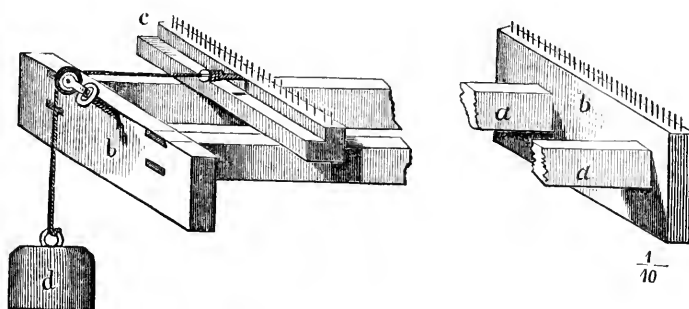
The plaster-knife is represented in fig. 494. It consists of an iron blade about ten inches in length, and, therefore, longer than the width of the plaster. It is flat on one side and convex on the other, as represented in the

section (fig. 495), which is drawn to its real size. It has a wooden handle at one end, by which it is used.

Plasters may be spread without much difficulty, as above described, so as to present a tolerably even and uniform surface, when the edges have been cut off. It is a great objection to such a method of operating, however, that the operator requires the aid of two assistants.

With the view of obviating the necessity for manual assistance in the process, I have adopted the following arrangement, which has been found to answer perfectly. A light wooden frame is constructed, which consists of two bars (*a a*, fig. 496), which run parallel to each

Fig. 496.



APPARATUS FOR SPREADING PLASTERS.

other, and are inserted into two end-pieces (*b b*). The side-bars are four feet in length; they are two and a half inches deep, and three quarters of an inch wide. They are fixed at a distance of five and a half inches from each other. The end-piece on the right hand side consists of a board, ten inches long, five and a half inches deep, and one inch in width. It has a row of pointed wires fixed in the top in the manner already described. The left hand end-piece (*b*) is level with the top of the side-bars. It is ten inches long, three and a half inches deep, and one inch in width. Midway between the two ends of this end-piece there is a pulley fixed as represented in the drawing, so that the top of the groove is at the same height as the wire points of the right hand end-piece. There is a movable cross-bar (*c*) which rests on the side-bars, and the top of which, when in such position, is at the same height as the top of the right hand end-piece, and, like the latter, it is furnished with a row of wire points.

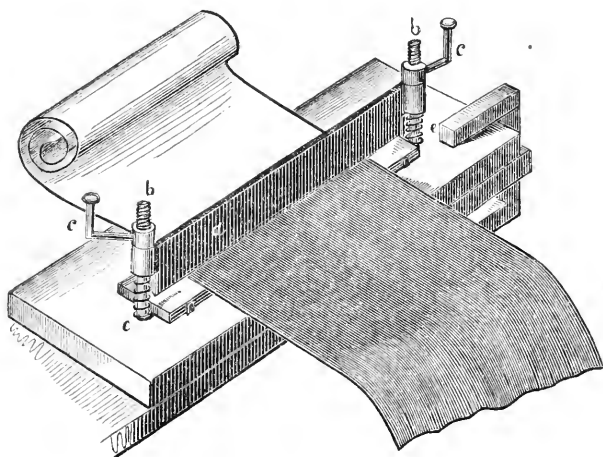
In using this apparatus the strip of cloth is fixed on the points in the manner already described, and a weight (*d*) of about fifteen or twenty pounds is attached to the movable cross-bar (*c*) by a cord.

The cloth is thus kept uniformly and constantly stretched by the action of the weight.

The instrument used for spreading the plaster is a hollow triangular vessel, filled with boiling water. A transverse section of it would form an equilateral triangle. At one end it has a wooden handle, and at the other, a short projecting tube, through which hot water is introduced, and this is subsequently stopped with a cork. It contains about eight ounces of water. This instrument, when charged with boiling water, will continue hot for some time, in consequence of the great capacity for heat which water has; and any plaster which may adhere to it after being used, is easily removed in consequence of its remaining soft.

The strips of cloth are sometimes stretched by means of a screw attached to one of the end-pieces of the frame, but this arrangement is less convenient than that in which the weight is used, because, although the cloth may be made tight before the spreading is commenced, it will often become loose during the process.

Fig. 497.



APPARATUS FOR SPREADING PLASTERS.

There is yet another method of spreading the plasters now under notice, which consists in drawing the cloth, on to which the plaster has been poured, beneath a straight blade of metal, which leaves only a thin and even coating of the plaster. In operating in this way, pieces of cloth of any length may be covered, which is a great advantage. Many forms of apparatus have been recommended for

this process, of which that represented in fig. 497 is one of the most simple.

Upon a solid oaken board, of suitable size, are fixed two screws (*b b*). These receive the cylindrical ends of the spreading-blade (*a*), which fits loosely on to the screws, and above them there are two nuts (*c c*), each of which has a small lever handle by which it is screwed on and off. The cylindrical ends of the blade (*a*) are only half the depth of the blade itself, and the threads of the screws (*b b*) extend only as low down as the nuts are required to be screwed. Surrounding the lower part of each screw, there is a strong spiral spring (*e e*), which presses the spreading-blade upwards, and keeps it in the exact position at which it has been adjusted by the nuts.

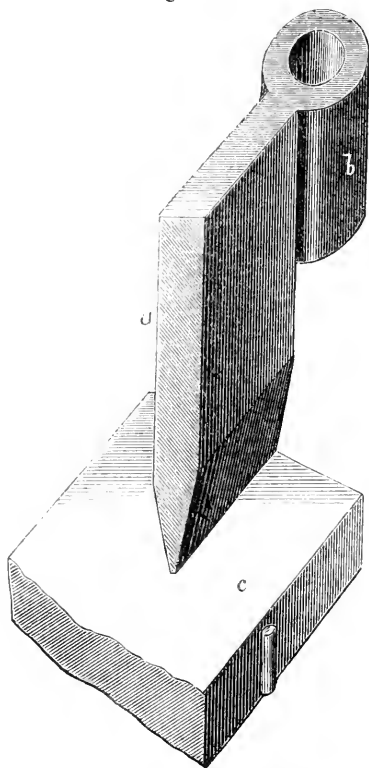
Immediately below the knife there is a smooth solid plate of iron, which is retained in its place by four small pegs fixed in the wood. On taking out the pegs, the iron plate is easily removed for the purpose of cleaning it, and again fixed in its place for use.

The edge of the spreading-blade, which is not sharp, but somewhat rounded, as shown in the section, fig. 498, should be perfectly straight and smooth, as also should be the surface of the metallic plate beneath it. In order to test the correctness of this part of the apparatus, the blade (*a*) should be screwed down by means of the nuts until it is almost in contact with the plate beneath, and then, holding it against the light, it should be observed whether the intervening space forms a straight and uniform streak.

Fig. 498 represents a section of the spreading-blade (*a*), with one of its cylindrical ends (*b*), and part of the metallic plate (*c*). One of the pegs by which the plate is kept in its place is also shown.

The following is the method of using this apparatus. In the first place the board is fixed to a table; then, a sheet of smooth writing-

Fig. 498.



paper is placed over the iron plate, beneath the edge of the blade, and fixed there by attaching it with a little gum or paste to the board. This paper receives the portions of plaster which run off in the process of spreading. Sometimes a small trough is placed in front of the blade to receive the surplus plaster, but the trouble of cleaning out the trough is greater than that of removing the plaster from the paper. The cloth is placed between the edge of the blade and the paper, and the blade is so adjusted, by means of the nuts, that while the cloth can be drawn through with tolerable facility, it nevertheless occasions some friction. The plaster, in a semifluid state, is now poured on to the cloth immediately behind the spreading-blade, and the cloth is drawn through, steadily and not too rapidly, on the opposite side. If the coating of plaster is found to be too thick, the blade must be depressed a little more, care being taken that this is done equally at both ends. Should a knot occur in the cloth, so as to prevent it from passing beneath the blade, it will be necessary to unscrew one or both of the nuts to admit of its passage, and then to restore the blade to its original position. It would be found advantageous to examine the cloth before commencing the spreading of the plaster, and to remove any knots that may be found in it. The examination is conveniently effected by passing the cloth through the apparatus, screwed rather close, before adding the plaster, the apparatus itself being the best test of the absence of knots.

The strips of plaster, after being spread, should be hung across a line in a cold cellar, and left there for ten or twelve hours, to harden. They may then be rubbed over with a little soap, which prevents their adhering together when rolled up.

Cerated cloth is made by drawing strips of calico or linen through a melted mixture of eight parts of white wax, four parts of olive oil, and one part of Venice turpentine; and subsequently, before the adhering mixture has cooled, passing the slips between two wooden rollers, by which the superfluous cerate is removed.

Court-plaster is prepared by spreading a solution of isinglass over the surface of silk. The solution is made by soaking two ounces of the best isinglass in sixteen ounces of water, and when the former has become soft, adding sixteen ounces of rectified spirit. The mixture is digested, with the heat of a water-bath, in a partially closed vessel, until solution has been effected, and the product is then strained through linen.

The silk on which the plaster is to be spread is stretched by means of an apparatus similar to fig. 496, and the solution is then laid on,

while in a fluid state, with a camel's-hair brush, several successive layers of it being applied as the preceding ones have become dry.

It is frequently recommended that a thin coat of an alcoholic solution of balsam of Peru, or resin of benzoin, should be applied over the surface of the last layer of isinglass; but this addition is of very questionable advantage, as it is apt to occasion irritation of the part to which the plaster is attached. The silk used for the purpose may be black, white, or flesh-coloured.

Transparent isinglass plaster is now frequently used for surgical purposes. It is made by spreading a solution of isinglass, similar to that above described, over the surface of oiled silk or animal membrane; the latter answers best. The peritoneal membrane of the cæcum of the ox is prepared expressly for this purpose. The best method of applying the gelatinous solution is, to stretch the moist membrane over the surface of a flat board, attaching it by small nails at its extreme edges. When the membrane has dried, the gelatinous solution is brushed over it with a flat varnishing brush, the motion of the brush being maintained in one direction, as in painting wood. This coating is allowed to dry spontaneously, and then another is applied in a similar way, only observing to move the brush in a direction at right angles with that previously adopted. Four or five coats are thus successively laid on, changing the direction of the brush each time, and using rather a thinner gelatinous solution for the last coat than for those preceding. When a sufficient coating of gelatin has been thus formed, the membrane is to be turned over on the board, so as to bring the uncoated surface upwards, and a thin coat of drying oil is to be applied on this side.

Blistering-tissue, which is sometimes substituted for the ordinary blistering-plaster, is prepared in the following way. Any quantity of powdered cantharides is treated with ether until it is entirely exhausted. This will be best effected by the use of the apparatus described at page 264, fig. 263. The ether is subsequently distilled off by the heat of warm water, when a greenish oily residue, of the consistence of butter, will be obtained. This is a powerful vesicating agent. It is mixed with twice its weight of melted white wax, and the mixture is spread in a very thin layer over the surface of paper. The spreading is best effected by means of the apparatus fig. 497.

Gout-paper is prepared in a similar way to that last described by spreading a mixture of an ethereal or a spirituous extract of the bark of mezereon root, with wax, spermaceti, and oil, over the surface of paper.

INHALATION.

The inhalation of the fumes of orpiment is said to have been practised in the time of Galen, and it is probable that from that time to the present, medicines in the state of vapour have been occasionally administered through the lungs.

In the latter part of the last century the attention of medical men was prominently directed to this method of combating disease, by Dr. Beddoes, who in conjunction with Mr. Watt and others, pursued a lengthened course of experiments, with the view of determining the action of various gases upon the human system, when inhaled. Sir Humphry Davy commenced his career as a chemist in the capacity of assistant to Dr. Beddoes, at the Pneumatic Institution, which was established at Clifton, about the year 1796, for the administration of gases.

More recently renewed interest has been excited with reference to the subject of inhalation, in consequence of the remarkable effects which have been found to result from the administration of the vapours of ether and chloroform.

It is probable that other substances, besides those which have hitherto been used in this way, will be found to admit of advantageous application, by administering them in a gaseous state through the lungs; and as chemists may expect to be applied to for assistance in devising the best methods of operating in such cases, it may be well to direct attention here to some of the conditions essential to the successful administration of gases, vapours, and fumes.

The terms *gas*, *vapour*, and *fume*, will be here used in their popular significations. By the term *gas* is meant an æriform fluid which retains this condition at all ordinary temperatures. The term *vapour* is used to signify a solid or liquid body which has assumed the æriform condition under the influence of heat, but which would return to its original state when exposed to a diminished temperature. The term *fume* signifies a vapour in the act of condensation, the condensed particles being still suspended in the surrounding air. Fumes are therefore distinguishable from gases and vapours in being visible, and more or less opaque. Medicinal agents are administered by inhalation in each of these three states.

Among the gases which have been employed therapeutically, are oxygen, nitrous oxide, and chlorine. These substances, as the term

applied to them indicates, being perfectly æriform, may be collected and retained, unmixed with other matter, in vessels suitable for their reception. They are administered either in a pure or a diluted state.

Oxygen gas has been sometimes given alone, but more frequently mixed with a portion of atmospheric air. The admixture may be made with perfect accuracy, by means of the usual pneumatic apparatus, and the mixed gases may be inhaled from a bladder or an oiled silk bag, or directly from a gasometer.

Nitrous oxide gas, like oxygen, is given either alone or mixed with atmospheric air. It is generally inhaled from a bladder or oiled silk bag.

Chlorine cannot be administered alone. Even when considerably diluted with common air the attempt to inhale it might prove fatal to the individual. Extremely minute quantities only, mixed with air, can be safely taken into the lungs. The usual and best method of administering this gas is, to put some warm water into the bottom of a bottle, such as fig. 499, furnished with two glass tubes inserted through a cork; to add about half an ounce of an aqueous solution of chlorine to the water; and then to inhale through the bent tube. The mouth-piece is not required in this case, the inhalation being effected from the open end of the bent glass tube. As the patient draws air out of the bottle through this tube, fresh air from without enters through the straight tube, and, passing in bubbles through the liquid, it carries a portion of chlorine with it, and thus becomes sufficiently charged with the gas. There is no danger, in this way, of getting too strong a dose.

The vapours of water, of acetic acid, of the volatile constituents of certain plants, of tar, &c., have long been occasionally applied by inhalation; and within the last year or two the vapours of ether and chloroform have been extensively administered in the same way, as anæsthetic agents. In all these cases the substances administered are incapable of existing in the æriform state at the temperatures at which they are inhaled, if exposed to the pressure of the atmosphere, and unmixed with permanent gases.

A liquid, water for instance, does not assume the æriform condition, so as to be capable of resisting the pressure of the atmosphere and occupying a space free from other matter, unless it has a large quantity of heat in combination with it, and is maintained at a temperature of at least 212° . Pure steam, therefore, cannot exist, under the pressure of the atmosphere, at a lower temperature than 212° . When the temperature falls below this point, condensation commences, and the

vapour, which was invisible, becomes, under certain circumstances, converted into a *fume*, which is visible steam containing a great number of minute globules of water, resulting from the condensation.

Other liquids, besides water, have certain temperatures at which they are capable of maintaining the aëriform condition under the pressure of the atmosphere, and these temperatures are called their boiling points, the boiling of a liquid being the result of its transition from the liquid to the aëriform state. Thus, ether boils at about 96° , and chloroform at 141° ; and at these, but not at lower temperatures, the vapours would be capable of occupying spaces free from other matter, and of being inhaled in a pure state.

But the vapours of many liquids, in common with gases, have a tendency to diffuse themselves through aëriform fluids, and if the space into which this diffusion takes place be occupied by a permanent gas, the diffused vapour will be capable of maintaining its aëriform condition under pressures and at temperatures at which it could not otherwise exist in this state. Thus, although the vapour of water is incapable of occupying a space free from other matter, under the pressure of the atmosphere, at a lower temperature than 212° , yet its vapour diffuses itself into atmospheric air and other permanent gases, and thus maintains the aëriform condition, at all common temperatures. So, in like manner, the vapours of ether, of chloroform, and other volatile liquids, readily diffuse themselves into air and gases generally, at low temperatures, and they thus become permanently aëriform under such conditions.

It is in the state of diffusion with atmospheric air that the volatile substances now under notice are administered by inhalation. The diffusion of the vapour of water, at temperatures below the boiling point of that liquid, has been already alluded to in treating of spontaneous evaporation at page 299, but the object there has been to show how diffusion affects the loss of a volatile liquid from an open vessel. Here, we have to consider the circumstances affecting the accumulation of the vapour of a volatile liquid in a space previously filled with air. These circumstances may be thus briefly stated.

If a jar, partly filled with dry air, be inverted over water in the pneumatic trough, and left there for some time, a portion of the water will become converted into vapour, and this will diffuse itself equally throughout the air, and will increase the volume of the aëriform contents of the jar, displacing part of the water. At length, the further accumulation of the vapour of water will cease; diffusion will now have taken place to the greatest extent possible under the circum-

stances. During the formation of the vapour of water, which thus becomes diffused into the air of the jar, a reduction of temperature takes place, in consequence of some of the sensible heat of the air and vaporizing liquid being rendered latent in the transformation of water into steam. The diffusion, however, will not permanently stop until the heat of the air in the jar has become equalized with that of surrounding objects, for the temperature of the air will be found to set the limit to the extent of diffusion. If, after diffusion has ceased, the temperature be reduced, a portion of the vapour will immediately be condensed; or if, on the other hand, the temperature be raised, a further portion of water will pass into vapour, which will undergo diffusion. The extent of surface of the liquid exposed to the air will influence the velocity with which diffusion takes place. The greater the surface exposed, the more rapid will be the vaporization and consequent diffusion.

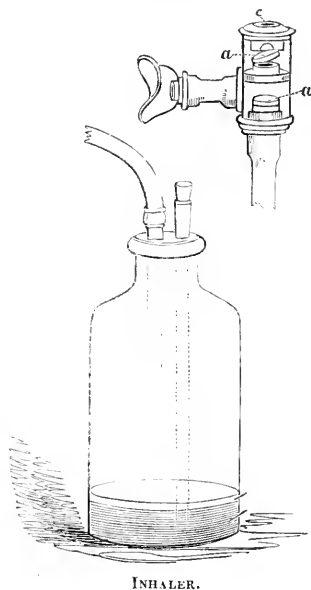
Such are the conditions which are found to influence the diffusion of the vapour of water, and the same conditions principally affect the results in other cases.

The quantity of the vapour of a volatile liquid that can diffuse itself into a given space filled with air, will depend upon the temperature maintained by the mixed atmosphere. It will be equal to the quantity that would diffuse itself into a vacuous space at the same temperature. The quantity will vary, however, at any one point of temperature, according to the nature of the liquid.

The velocity with which the diffusion of the vapour of a volatile liquid takes place into a given space filled with air, will depend upon the nature of the liquid, the extent of surface exposed, and the temperature at which the diffusion occurs. It will be much less rapid than it would be if it took place into a vacuous space.

The most generally applicable form of apparatus for the purpose of administering diffused vapours by inhalation, is that represented in fig. 499. It consists of a wide-mouthed

Fig. 499.

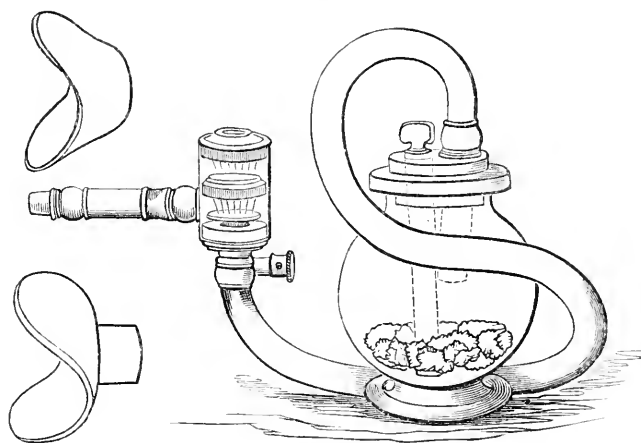


It consists of a wide-mouthed

bottle, to which two tubes are adapted by means of a cork. The straight tube dips into the liquid at the bottom of the bottle, and is open at both ends; the bent tube passes only into the upper part of the bottle, and the other end of it is applied to the mouth. Its use in this way has been already described in alluding to the inhalation of chlorine. The same form of apparatus has been employed for inhaling the vapour of ether. In this case the ether is allowed to float on the surface of some water at the bottom of the bottle, and the vapour, having diffused itself into the air above, is inhaled through the bent tube, to the end of which the valved mouth-piece is attached. The latter is intended to prevent the expired air from passing into the apparatus. The valves *a* and **a*, are two disks of glass, each resting on a short piece of tube, and the whole contained in a larger tube, the opening to the mouth-piece being midway between the two valves. On inspiring, the lower valve opens and the upper one remains closed; on expiring, the lower one is closed, and the upper valve opens, and allows the expired air to pass out through the orifice *c*.

Inhalers are made on the above principle, but without the valved mouth-piece, in metal, and such are used for inhaling the vapour of hot water, acetic acid, &c.

Fig. 500.



ETHER INHALER.

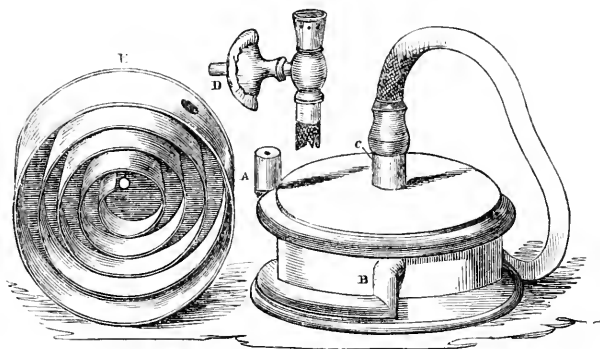
In administering the vapour of ether, it is desirable to promote rapid vaporization and diffusion, and for this purpose a more extended evaporating surface is required than the stratum of liquid at the

bottom of the bottle presents. This is provided by introducing into the bottle some pieces of sponge wetted with ether, as shown in fig. 500. This apparatus is similar in principle to the preceding. The straight tube through which the air enters the apparatus is furnished with a stopper by which the loss of ether is prevented when the apparatus is not in use.

The valved mouth-piece, represented in figs. 499 and 500, was first made by Mr. Gilbertson at the suggestion of Mr. Bell. The valves, and also the mouth-pieces are made of glass, and the latter may be taken off and washed after using the instrument. There is a great advantage in the glass valves, which is, that the operator can judge, by the action of the valves, which are visible, of the quantity of vapour that the patient is inhaling. When the inhalation ceases, the valves, of course, remain closed.

Dr. Snow has recommended a form of apparatus for inhaling ether, which, in addition to an extended evaporating surface, offers facilities for regulating the temperature, and thus enables the operator to judge of the proportion of ether vapour contained in the inspired air. Fig. 501 represents this inhaler.

Fig. 501.



ETHER INHALER.

- | | |
|---|---|
| A. Opening of pipe at which the air enters. | D. Mouth-piece. |
| B. Termination of pipe in the tin box. | E. Tin vessel, with the bottom removed, to show its interior. |
| C. Point at which the flexible tube is removable by unscrewing. | |

It consists of a round tin box, two inches deep, and four or five inches in diameter, with a tube of flexible white metal, half an inch in diameter, and about a foot and a half long, coiled round and soldered to it. There is an opening in the top of the vessel, at its centre, for putting in the ether, and afterwards attaching the flexible tube belonging to the mouth-piece. In the interior is a spiral plate

of tin, soldered to the top, and reaching almost to touch the bottom. When used, the inhaler is to be put in a hand-basin of water, mixed to a particular temperature, corresponding to the proportion of vapour that the operator may desire to give; and the caps being removed, and the mouth-piece attached, when the patient begins to inhale, the air gains the desired temperature in passing through the metal pipe; it then comes upon the surface of the ether, where it winds round three or four times before entering the tube going to the mouth-piece, thus insuring its full saturation, and preserving it at the desired temperature. There is no valve, or any other obstruction to the air, till it reaches the mouth-piece, which is of the kind used in other inhalers, and contains the valves necessary to prevent the return of the expired air into the apparatus.

Dr. Snow has published the following table, which indicates the proportions of ether vapour and air in saturated mixtures at the several temperatures named.

Temp. Fahr.	CUBIC INCHES.		WEIGHT IN GRS.		Temp. Fahr.	CUBIC INCHES.		WEIGHT IN GRS.	
	Ether.	Air.	Ether.	Air.		Ether.	Air.	Ether.	Air.
40°	24·3	75·7	19·1	23·1	66°	45·3	54·7	35·7	16·6
42	25·6	74·4	20·1	22·7	68	47·4	52·6	37·3	16·0
44	27·0	73·0	21·2	22·2	70	49·4	50·6	38·9	15·4
46	28·3	71·7	22·3	21·8	72	51·5	48·5	40·6	14·7
48	29·7	70·3	23·4	21·4	74	53·6	46·4	42·2	14·1
50	31·2	68·8	24·6	20·9	76	56·0	44·0	44·1	13·4
52	32·7	67·3	25·8	20·5	78	58·4	41·6	46·0	12·6
54	34·3	65·7	27·0	20·0	80	61·0	39·0	48·1	12·0
56	36·0	64·0	28·3	19·5	82	63·7	36·3	50·2	11·0
58	37·7	62·3	29·7	19·0	84	66·6	33·4	52·5	10·1
60	39·5	60·5	31·1	18·4	86	69·5	30·5	54·8	9·3
62	41·4	58·6	32·6	17·8	88	72·5	27·5	57·1	8·3
64	43·3	56·7	34·1	17·3	90	75·6	24·4	59·6	7·4

At about 45° the *weights* of vapour of ether and of air are equal, and at a little above 70° the *volumes* are equal.

The weights are calculated with the barometer at 30.

For the inhalation of the vapour of chloroform, of which only a very small quantity is required to produce the desired effect, more simple forms of apparatus than those used for ether, are employed. A handkerchief, twisted into a hollow cone, moistened with a few drops of chloroform, and held over the mouth of the patient, is the

usual method adopted for administering this vapour in Scotland by Dr. Simpson, and other eminent surgeons.

Fig. 502.

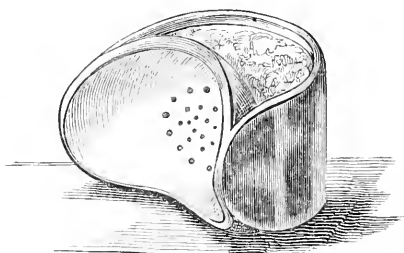
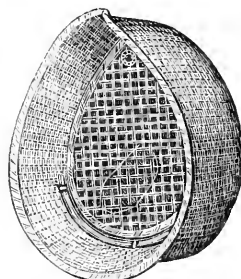


Fig. 503.



CHLOROFORM INHALERS.

Figs. 502 and 503 represent chloroform inhalers. The former consists of a perforated metallic plate, which is placed over the mouth of the patient, and in front of which there is a trough containing some sponge moistened with chloroform. This apparatus also answers very well for administering the vapour of ether. The apparatus fig. 503, is made of basket-work. A sponge, wetted with chloroform, is put into the inner part of the apparatus, and this is covered by a diaphragm, which intervenes between it and the mouth of the patient.

Dr. Snow uses an inhaler for administering the vapour of chloroform, which is constructed on a similar principle to that of his ether inhaler, so that a regulated temperature can be maintained during the process. He states that 100 cubic inches of air will take up the following quantities of the vapour of chloroform at the temperatures indicated:—

Temperature.	Cubic inches.
50°	9
55	11
60	14
65	19
70	24
75	29
80	36
85	44
90	55

The vapour of tar has been administered by boiling common tar,

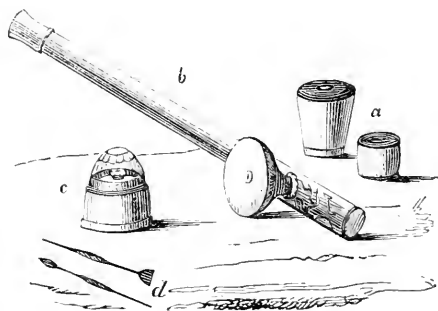
together with some water, over a lamp or chauter in the apartment occupied by the patient, and allowing the vapours to diffuse themselves through the room.

There are some substances which are occasionally administered by inhalation, but which cannot be introduced into the lungs as perfectly aëriform fluids, in consequence of their existing in that state only at high temperatures, and being incapable of diffusion. They are, therefore, inhaled as *fumes*, the vapours being more or less condensed, and the resulting solid or liquid particles being suspended in the air, and thus conveyed to the lungs. Sulphuret of mercury is sometimes administered in this way, and it is thus also that orpiment has been inhaled. The inhalation is usually effected in cases such as those named by sprinkling the substance, in powder, on to a hot brick or a hot iron, such as a shovel, which has been heated to dull redness in the fire, while the patient inhales the fumes which are carried upwards in the current of heated air. Any attempt to convey the fumes through a tube, unless there be a current of air passing through it, would be ineffectual. There are some cases, however, in which a tube is used for inhaling fumes, as for instance, in smoking tobacco.

The smoking of opium is an operation in which an active medicinal agent is administered by inhalation in the form of fume or vapour. The great energy exerted by the active principle of the opium under these circumstances, seems to indicate that medicines, not usually accounted volatile, might be thus applied with advantage.

Fig. 504 represents the apparatus employed in China for smoking opium, and it may suggest the application of suitable means in other

Fig. 504.



similar cases. The opium is not used in its crude state; an aqueous extract of it is carefully prepared, which is kept in small pots (*a*).

The pipe (*b*) consists of a wooden tube, near to one end of which is fixed an earthen bowl, of a conical form, having a small aperture in the centre of the top. A lamp (*c*) is used in the process, and also the small iron instruments *d*.

The smoker having lighted the lamp, lays his head upon a pillow ; taking a small portion of the extract of opium upon the point of one of the instruments (*d*), he ignites it in the lamp, then introduces it into the bowl of the pipe through the aperture at the top, applies the bowl to the flame so as to heat it, and inhales the smoke at the open end of the tube. A whiff or two is all that is derived from a single charge of the pipe, and yet this is sufficient to produce the soothing effects of the narcotic drug.

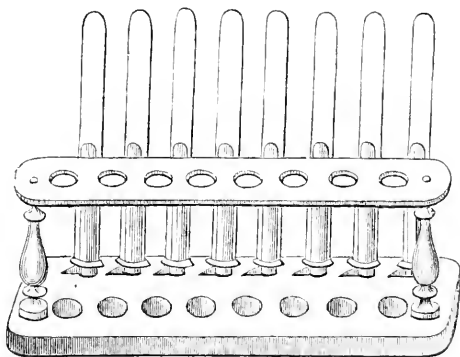
CHAPTER XVIII.

[APPARATUS FOR TESTING. REAGENTS. DIRECTIONS FOR ASCERTAINING THEIR PURITY.

APPARATUS FOR TESTING.

THE pharmacist, although not a professed analytical chemist, and not possessed of the requisite apparatus for conducting many of the processes required in analysis, is nevertheless frequently called upon, both for his own satisfaction and at the request of physicians, to perform qualitative examinations of substances. The disposition which exists to adulterate commercial chemicals is so great, that he has constantly to be on the alert to avoid being imposed upon. A pharmaceutical establishment should therefore be provided with a set of reagents, a rack of test-tubes, a dozen watch-glasses, a small platinum crucible, or capsule, or in the absence of these, a piece of thick platina foil, a blowpipe, a few glass bulbs blown on tubes, test-

Fig. 505.



papers, a glass alcohol lamp, a set of small porcelain capsules, a small lamp-stand, half a dozen small glass funnels, some good filter-paper, and a bottle of test-papers. These should be kept in a case, or closet, near

at hand, where resort can be had to them at any moment. When the apothecary has had no tuition in this branch of chemistry, he can render himself sufficiently acquainted with the general details of qualitative analysis, and become familiar with the action of tests, by experimenting with reagents on known compounds. The following list of reagents, and the directions for ascertaining the purity of tests and their principal uses, is taken verbatim from Bowman's Practical Chemistry, which little work strongly recommends itself to the pharmacist.

REAGENTS.

The following is a list of the reagents, &c., usually employed in testing and analysis:—

Sulphuric acid, strong and dilute.

Hydrochloric acid.

Nitric acid.

Nitrohydrochloric acid (aqua regia).

Oxalic acid.

Acetic acid.

Tartaric acid.

Hydrosulphuric acid (sulphuretted hydrogen).

Ammonia.

Hydrosulphate of ammonia.

Carbonate of ammonia.

Oxalate of ammonia.

Phosphate of soda and ammonia (microcosmic salt).

Potash.

Carbonate of potash.

Nitrate of potash.

Iodide of potassium.

Chromate of potash.

Cyanide of potassium.

Ferrocyanide of potassium (yellow prussiate of potash).

Ferridecyanide of potassium (red prussiate of potash).

Antimoniate of potash.

Carbonate of soda.

Phosphate of soda.

Borax.

Lime water.

Sulphate of lime.
Chloride of calcium.
Chloride of barium.
Nitrate of baryta.
Perchloride of iron.
Nitrate of cobalt.
Sulphate of copper.
Ammonio-sulphate of copper.
Acetate of lead.
Subacetate of lead.
Nitrate of silver.
Ammonio-nitrate of silver.
Perchloride of mercury.
Protochloride of tin.
Perchloride of gold.
Bichloride of platinum.
Sulphate of indigo.
Solution of starch.
Black flux.
Distilled water.
Alcohol.
Litmus and turmeric paper.

DIRECTIONS FOR ASCERTAINING THEIR PURITY.

Most of these substances, as they are met with in commerce, being always more or less impure, and, as those even which are sold in the shops as pure reagents, are not unfrequently found, on examination, to be otherwise; it is always necessary, before taking a reagent into use, to ascertain by experiment whether it is of sufficient purity for the purposes for which it is intended. It may be stated as a general rule, that, when a chemical substance is required for use in analysis, it ought to be as nearly pure as possible; while, for many of the other operations of chemistry, the substances which are usually met with in commerce are sufficiently pure. The following brief remarks relative to the more common impurities of reagents, together with their principal uses, will probably be found useful to the student.

Sulphuric Acid (HO,SO_3).

Sulphuric acid, as found in commerce, is never pure. The most

common impurities are sulphate of lead, nitric acid, or binoxide of nitrogen, and occasionally arsenic, and other saline matters.

(a) If it contains the first, it will become turbid when diluted with four or five times its bulk of water, owing to the sulphate of lead, which is soluble in strong acid, being insoluble in the dilute.

(b) Nitric acid, or the binoxide of nitrogen, is detected by warming a little of the acid in a test tube with a small crystal of protosulphate of iron; or by boiling a small portion tinged with a solution of sulphate of indigo, when, if nitric acid is present, the blue colour will disappear.

(c) Arsenic may be detected by Marsh's test.

(d) Any fixed saline impurity remains as a residue when a few drops of the acid are evaporated on platinum foil.

The uses of sulphuric acid are very numerous. Besides being employed extensively in many branches of manufacture, it is used in the laboratory as a powerful decomposing agent; owing to its strong affinity for bases, nearly all saline compounds are decomposed by it, and its solvent powers are also very great. It is often employed for the purpose of decomposing organic matter; also in the preparation of hydrogen, hydrosulphuric acid, and other gases; as a test for certain metals, and for many other purposes.

When *dilute* sulphuric acid is required, it is prepared by mixing together one part of the strong acid with four parts of distilled water, always *adding the acid to the water*, which should be kept constantly stirred, and allowing the precipitated sulphate of lead (if any) to subside, after which the clear liquid may be poured off.

Hydrochloric Acid (HCl).

This acid, in the form met with in commerce, is never pure, usually containing sulphuric acid and chloride of iron, and occasionally free chlorine and traces of arsenic.

(a) Evaporate a drop or two on platinum foil: if pure, no residue is left.

(b) Dilute a portion with four or five times its bulk of distilled water, and add a drop of chloride of barium: if sulphuric acid is present, a white precipitate is produced.

(c) Add ammonia in excess: a brown precipitate indicates iron.

(d) Boil a little of the acid, tinged with sulphate of indigo: if it contains free chlorine, the blue colour is bleached.

(e) Arsenic may be detected by Marsh's test.

The uses of hydrochloric acid are very numerous, especially in analysis, in which it is of constant value as a solvent for substances which are insoluble in water; most of the metals dissolve readily in it, forming soluble chlorides, and it is occasionally used to precipitate silver and mercury from their solutions.

When *dilute* hydrochloric acid is required, the strong acid may be diluted with about twice its bulk of water.

Nitric Acid (HO, NO_3).

Nitric acid, as met with in commerce, usually contains sulphuric and hydrochloric acids, and occasionally a little fixed saline matter.

(a) The latter may be detected by evaporating a few drops on platinum foil, when any fixed impurities will be left.

Dilute a little of the acid with water, and divide it into two portions.

(b) To the first, add chloride of barium: if a white precipitate is produced, sulphuric acid is present.

(c) To the other add nitrate of silver: a white precipitate, soluble in ammonia, indicates hydrochloric acid.

Nitric acid is used chiefly as a solvent for substances which are insoluble in water, especially some of the metals, which it readily oxidizes, and converts into nitrates, nearly all of which are soluble in water. It is, also, frequently employed to raise compounds to a higher state of oxidation, as in converting the protoxide of iron into the peroxide.

When *dilute* nitric acid is required, it may be prepared by mixing one part of the strong acid with two parts of distilled water.

Nitrohydrochloric Acid (*Aqua Regia*).

This is always prepared when required, by mixing together strong nitric and hydrochloric acids, usually in the proportion of one part of nitric to four of hydrochloric. Its chief uses depend on its intense oxidizing or chlorinizing properties, whereby the most refractory metals, some of which resist the action of all other acids, are brought into solution.

Hydrosulphuric Acid (HS). (*Sulphuretted Hydrogen*.)

This reagent, whether required in the gaseous form or in solution,

is always prepared in the laboratory. Fragments of sulphide (sulphuret) of iron (FeS) are placed in a bottle, *a*, and treated with dilute sulphuric acid (which for this purpose should consist of one part of acid and eight parts of water), which disengages the gas. The gas thus formed, is passed through water contained in the second bottle, *b*, for the purpose of purifying it from any

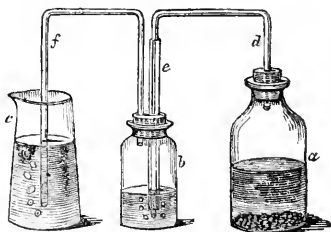
sulphuric acid and iron that may have been carried over mechanically, and is then conducted by the bent tube, *f*, into a bottle of distilled water, when an aqueous solution of the gas is required, or into a jar containing any solution which it is intended to act upon.

In most cases of mere testing, the aqueous solution is the most convenient form in which to apply it. The water should be saturated with the gas, of which it is capable of retaining in solution about its own volume; this may be judged of by its strong disagreeable smell, resembling that of rotten eggs, and by its giving a copious white precipitate of sulphur when treated with perchloride of iron. It should also be tested for iron, which it sometimes contains when carelessly prepared: if such is the case, it becomes dark coloured on the addition of ammonia, owing to the formation of sulphide of iron. The solution should not be kept long, as it is liable to decompose, unless carefully kept from the air, the oxygen of which combines with the hydrogen to form water, while sulphur is deposited.

When it is required to precipitate, by hydrosulphuric acid, *the whole* of any metal in a solution, it is necessary to pass the gas at once into it; and this should be continued until the liquid is saturated, which is known by removing the gas-delivering tube, and blowing away the superincumbent air, when, if it smells distinctly of the gas, the solution may be considered saturated, and the whole of the metal must have been converted into sulphide.

The important uses to which hydrosulphuric acid is applied, render it of great value in many processes of analysis. It precipitates many of the metals from their solutions as insoluble sulphides, and is one of the reagents employed in determining the class to which an unknown metal in solution belongs. It is also extensively used in quantitative analysis, on account of the perfect manner in which it separates the whole of many of the metals from their solutions. Hydrosulphuric acid is also sometimes useful as a deoxidizing agent, reducing metallic

Fig. 506.



oxides in solution to a lower degree of oxidation, as the peroxide of iron to the protoxide: this property is owing to the facility with which it is decomposed, yielding up its hydrogen to the oxygen of the oxide, while the sulphur is usually set free.

Oxalic Acid ($\text{HO}, \text{C}_2\text{O}_3$).

Oxalic acid occasionally contains traces of nitric acid (which causes it to deliquesce in damp air, and to have a slightly acid smell), and also fixed saline matter.

(a) The first may be detected by boiling the solution with a drop or two of sulphate of indigo.

(b) The latter, if present, is left as a fixed residue after ignition on platinum foil.

It is easily purified by recrystallization.

The chief use to which oxalic acid is applied in analysis, is to precipitate lime from its solutions. (See also *Oxalate of Ammonia*.) For use as a test, one part of the crystallized acid may be dissolved in ten parts of water; but, as the solution is liable to decompose, it is better to keep it in the solid state, and to dissolve a little when wanted.

Acetic Acid ($\text{HO}, \text{C}_4\text{H}_3\text{O}_3$).

This acid is often contaminated with one or more of the following substances: sulphuric, sulphurous, hydrochloric, and nitric acids, lead, and other saline matter.

(a) Any fixed impurity may be detected by heating a little on platinum foil.

(b) Add to a portion of the diluted acid, a solution of chloride of barium: if sulphuric acid is present, a white precipitate, insoluble in nitric acid, is thrown down.

(c) Boil a little of the acid with a very small quantity of peroxide of lead: if the latter becomes white (owing to its conversion into sulphate of lead), sulphurous acid is present.

(d) Nitrate of silver, added to the diluted acid, gives a white curdy precipitate, which is insoluble in nitric acid, if any hydrochloric acid is present.

(e) Boil a little of the acid, tinged with sulphate of indigo: if the colour is bleached, it is probably owing to the presence of nitric acid.

(f) Neutralize a small portion with ammonia, and add hydro-sulphuric acid or hydrosulphate of ammonia: if lead or any other

metallic matter is present (except the alkalies and alkaline earths) a precipitate is produced.

Acetic acid is chiefly employed in the laboratory as a solvent, and for the purpose of acidifying solutions, in cases where hydrochloric and nitric acids would act prejudicially.

Tartaric Acid ($2\text{HO}, \text{C}_8\text{H}_4\text{O}_{10}$).

Tartaric acid sometimes contains a trace of lime and sulphuric acid, but is usually sufficiently pure for analytical purposes. The lime may be detected by neutralizing a portion with ammonia, and adding oxalate of ammonia; and the sulphuric acid by chloride of barium.

Tartaric acid is used as a test for potash, with which it forms a sparingly soluble bitartrate. Its property of preventing the precipitation of iron and some other metals by the alkalies, is occasionally made available in analysis. It should be kept in the solid state, and a solution made when required, as when kept in solution it soon becomes mouldy; for this purpose, the crystallized acid may be dissolved in about three times its weight of water.

Ammonia (NH_3).

The liquid ammonia of the shops is generally sufficiently pure for most purposes of analysis; it sometimes, however, contains traces of carbonate, sulphate, and muriate of ammonia, and occasionally chloride of calcium. The carbonate is detected by adding lime water; the sulphate by supersaturating with dilute nitric or hydrochloric acid, and testing with chloride of barium; the muriate of ammonia may be detected by supersaturating with nitric acid, and adding nitrate of silver; and the lime (chloride of calcium) with oxalate of ammonia.

Ammonia is used chiefly for the purpose of neutralizing acid solutions, and for precipitating metallic oxides from their solutions, most of which are decomposed by it.

Hydrosulphate of Ammonia ($\text{NH}_4\text{S}, \text{HS}$).

Hydrosulphate of ammonia is prepared by passing a stream of hydrosulphuric acid gas through a solution of ammonia until it is saturated. To ascertain whether the saturation is complete, a few drops may be tested with sulphate of magnesia; if the ammonia is saturated, this gives no precipitate; but if any free ammonia is left,

it throws down the hydrate of magnesia. When first prepared, the solution is almost colourless, but it gradually becomes yellow, owing to partial decomposition, the oxygen of the air combining with the hydrogen, while sulphur is set free, and remains dissolved; when this decomposition has taken place, the addition of an acid causes not only the evolution of hydrosulphuric acid, but also precipitates the dissolved sulphur.

Hydrosulphate of ammonia is much used, both in qualitative and quantitative analysis, chiefly for the purpose of precipitating certain metals from their solutions, and for separating the metals of the third class from the alkalies and alkaline earths.

Carbonate of Ammonia ($2\text{NH}_4\text{O}, 3\text{CO}_2$).

The common carbonate of ammonia is a sesquicarbonate, or a compound of the neutral carbonate and the bicarbonate. When the neutral carbonate is required, and it is the best suited for most purposes of analysis, it may be prepared in solution by dissolving one part, by weight, of the crystallized sesquicarbonate in three or four parts of water, and adding one part of liquid ammonia (sp. gr. 0.96). It is frequently employed in analysis, to precipitate some of the metals as carbonates: it is also used to neutralize acid solutions, and for other purposes.

It is occasionally contaminated with traces of animal oil, and sulphate and muriate of ammonia.

(a) Heat a small fragment on platinum foil: if any fixed saline impurity is present, it will be left after ignition; and if any charring takes place, it indicates the presence of animal matter.

(b) Supersaturate a little of the solution with nitric acid, and add to one portion a few drops of chloride of barium: a white precipitate insoluble in nitric acid, indicates sulphuric acid.

(c) To the other portion of the acid solution, add nitrate of silver: if any muriate of ammonia is present, it will cause a white curdy precipitate.

Oxalate of Ammonia ($\text{NH}_4\text{O}, \text{C}_2\text{O}_3 + \text{Aq}$).

This salt, as met with in the shops, is sufficiently pure for all purposes of analysis. Like oxalic acid, it is employed chiefly for the purpose of precipitating lime from its solutions; for this purpose it may be dissolved in about six times its weight of water.

Phosphate of Soda and Ammonia (Microcosmic Salt).

This salt occasionally contains traces of chloride of sodium, which may readily be detected by adding a few drops of nitrate of silver to a solution of the salt, acidified with nitric acid, when a curdy white precipitate indicates the presence of the chloride.

Microcosmic salt is used almost exclusively in blowpipe experiments: when heated, it is decomposed, the ammonia and water are expelled, and soda, with excess of phosphoric acid, is left.

Potash (KO).

On account of its strong affinity for many substances, and its property of readily decomposing others, caustic potash is rarely found free from impurities. Those most commonly met with are organic matter, sulphate and carbonate of potash, chloride of potassium, silicic acid, and alumina.

(a) If organic matter is present, the solution of potash is more or less brown, and, on evaporation, leaves a brown residue.

(b) Sulphuric acid is detected by diluting the potash with water, supersaturating with nitric or hydrochloric acid, and adding chloride of barium, when, if it is present, the white insoluble sulphate is thrown down.

(c) If carbonic acid is present, lime water causes a white precipitate, which is soluble with effervescence when the solution is supersaturated with hydrochloric acid.

(d) A little of the diluted solution is supersaturated with nitric acid, and tested with nitrate of silver: a white curdy precipitate, soluble in ammonia, indicates chlorine or chloride of potassium.

(e) Neutralize a small portion with hydrochloric acid, and evaporate to dryness: if the residue is not wholly soluble in hydrochloric acid, silica is probably present.

(f) If alumina is present, it will be precipitated when the potash solution is neutralized with hydrochloric acid, and treated with a *slight* excess of ammonia.

Potash is used chiefly for the purpose of precipitating some of the metallic oxides from their saline solutions, which it does on account of its strong affinity for the acids with which they were in combination. It is employed also for neutralizing acid solutions, decomposing organic compounds, and many other purposes. A solution of potash

having a specific gravity of about 1060, is a convenient strength for most analytical purposes.

Carbonate of Potash ($\text{KO}, \text{CO}_2 + 2\text{Aq}$).

This salt generally contains traces of sulphate and chloride, and occasionally silica and alumina.

(a) A solution, supersaturated with nitric acid, and tested with chloride of barium, gives a white precipitate if any sulphuric acid is present.

(b) A solution similarly acidified, gives, with nitrate of silver, a white curdy precipitate, if it contains chloride of potassium.

(c) Neutralize a portion of the solution with hydrochloric acid, and evaporate to dryness: if the residue does not wholly dissolve when treated with hydrochloric acid, silica is probably present.

(d) If carbonate of ammonia causes, in a neutralized solution, a white gelatinous precipitate, alumina is probably present.

Carbonate of potash is frequently employed to precipitate metallic oxides and carbonates from their soluble combinations, and for the purpose of neutralizing acid solutions.

Nitrate of Potash (KO, NO_3).

Nitrate of potash often contains traces of sulphate and chloride, and occasionally nitrates of soda and lime.

(a and b) The sulphate and chloride may be detected with chloride of barium and nitrate of silver.

(c) If lime is present, it causes a precipitate when the solution is treated with oxalate of ammonia.

(d) The presence of nitrate of soda causes the salt to deliquesce in a moist atmosphere.

It is used almost exclusively in the dry state, for the purpose of oxidizing substances which resist other methods of oxidation; this property is owing to the oxygen of the nitric acid being loosely combined, and at a high temperature readily yielded up to any substance which has a strong affinity for it, such as sulphides, organic matters, &c.

Iodide of Potassium (KI).

Iodide of potassium is often adulterated with carbonate of potash;

sulphate of potash and chloride of potassium are also often present. It should always be in the form of well-defined (cubical) crystals, as the adulterated varieties are readily distinguishable by their imperfect crystalline form.

(a) Add a little dilute hydrochloric acid; if effervescence takes place, some carbonate is present.

(b) If sulphates are present, they may be detected by adding chloride of barium, which will, in that case, cause a white precipitate, insoluble in nitric acid.

(c) Add a little nitrate of silver; this will cause a pale yellow precipitate of iodide of silver, together with chloride of silver, in case any soluble chloride is present. To separate them, filter the mixture, and after washing the precipitate, treat it with a slight excess of ammonia, which dissolves the chloride (if any), and leaves the iodide undissolved: on neutralizing the ammoniacal solution with nitric acid, the appearance of a white curdy precipitate indicates the presence of a chloride.

Iodide of potassium is employed chiefly as a test for lead, mercury, and occasionally some of the other metals. For use as a reagent, one part of the salt may be dissolved in ten parts of water.

Chromate of Potash (KO, CrO_3).

This salt occasionally contains traces of sulphate of potash, which is readily detected by precipitating a little of the solution with nitrate of baryta, and adding an excess of nitric acid, which redissolves the chromate of baryta, while any sulphate remains insoluble.

It is employed as a test for several of the metallic oxides, with many of which it forms insoluble salts (chromates) of characteristic colours, as the chromate of lead, which is bright yellow. For use as a reagent it may be dissolved in ten times its weight of water.

Cyanide of Potassium (KCy).

Cyanide of potassium is sometimes used in blowpipe experiments, and also as a liquid test. It should be colourless, and entirely soluble in water.

Ferrocyanide of Potassium ($\text{K}_3\text{FeCy}_3 + 3\text{Aq}$). (*Yellow Prussiate of Potash*.)

This salt, as met with in commerce, is sufficiently pure for the pur-

poses of testing. It is employed as a test for the persalts of iron, with which it forms a deep blue precipitate of sesquiferrocyanide of iron, or prussian blue. It gives characteristic precipitates, also, with some other metals. For use as a reagent one part of the salt may be dissolved in fifteen or twenty parts of water.

Ferridecyanide of Potassium ($K_3Fe_2Cy_6$). (*Red Prussiate of Potash*.)

It occasionally contains traces of the yellow prussiate, which is easily detected by the solution giving a blue precipitate with perchloride of iron. It is used as a test for the protosalts of iron, with which it forms a blue precipitate of ferridecyanide of iron, which is similar in appearance to that formed by ferrocyanide of potassium with the persalts. It may be dissolved in ten or fifteen parts of water.

Antimoniate of Potash (KO, SbO_5).

This substance seldom or never contains any impurity that can interfere with its action as a test for soda, which is the only use to which it is applied in the laboratory. It must be kept in a well-stoppered bottle, and carefully excluded from the air, as the carbonic acid is liable to decompose it, and cause a precipitation of antimonie acid.

Carbonate of Soda ($NaO, CO_2 + 10Aq$).

The best method of preparing pure carbonate of soda, is to ignite the crystallized bicarbonate, when the second equivalent of carbonic acid and the water are expelled, and pure anhydrous carbonate is left. The salt of commerce frequently contains a little sulphate and chloride, which may be detected in the manner already detailed. The more impure varieties contain also traces of sulphide of sodium, and sulphite and hyposulphite of soda. These may be detected by adding dilute sulphuric acid and passing the evolved gas into a solution of acetate of lead; this should cause a white precipitate of carbonate of lead, and not a brown one; and no precipitation of sulphur should take place on the addition of the acid.

It is employed for the same purposes as carbonate of potash; also as a flux for the blowpipe, and for fusing with insoluble silicates, &c. For use as a liquid reagent, one part of the salt may be dissolved in ten parts of water.

Phosphate of Soda ($2\text{NaO}, \text{HO}, \text{PO}_5 + 24\text{Aq}$).

This salt sometimes contains a little sulphate and chloride. To detect these impurities add to one portion in solution, chloride of barium, and to the other nitrate of silver, and supersaturate both with nitric acid: if the precipitate does not entirely dissolve in either case, a sulphate or chloride is present.

It is employed chiefly as a test for magnesia, with which it forms, in the presence of ammoniacal salts, the double phosphate of magnesia and ammonia. For the purposes of testing, it may be dissolved in ten parts of water.

Borax (*Biborate of Soda*), ($\text{NaO}, 2\text{BO}_3 + 10\text{Aq}$).

Borax occasionally contains traces of sulphate and chloride, which may be detected in the same way as in the phosphate of soda. It is employed almost exclusively as a flux in blowpipe experiments, for which purpose it is admirably adapted: the second equivalent of boracic acid which it contains, exerts a strong affinity for bases at a high temperature, and is capable of displacing several acids from their combinations; it also forms many double compounds and mixtures which are readily fusible.

Lime Water (CaO in water).

This reagent is prepared by digesting hydrate of lime in cold distilled water for an hour or two, stirring the mixture occasionally, and, when the undissolved portion of the lime has subsided, pouring off the clear solution, and filtering if necessary. As it is liable to spoil when exposed to the air, owing to the absorption of carbonic acid, it should be kept in a well-stoppered bottle.

Lime water should be sufficiently strong to turn the yellow colour of turmeric instantly and decidedly brown; and, when tested with carbonate of soda, should throw down a copious white precipitate of carbonate of lime. It is used as a test for carbonic acid and some of the organic acids; for expelling ammonia from its combinations, and for many other purposes.

Sulphate of Lime ($\text{CaO}, \text{SO}_3 + 2\text{Aq}$).

Sulphate of lime being very sparingly soluble in water, is always

used in the form of a saturated solution, which is prepared by digesting the sulphate in water, stirring it occasionally, and pouring off the clear solution from the undissolved portion. It is used chiefly as a test for some of the organic acids, and for distinguishing baryta from strontia. The solution ought to give an immediate precipitate of sulphate of baryta, when tested with chloride of barium.

Chloride of Calcium (CaCl).

This substance occasionally contains a little free acid, and traces of iron. The first is detected by test-paper, and the latter, if present, causes hydrosulphate of ammonia to throw down in the solution a black precipitate, or to impart a greenish tint to the liquid. As a reagent, chloride of calcium is employed chiefly in testing for some of the organic acids. It is also of great use in the laboratory as a drying agent, having so strong an affinity for water, that a moist gas passed over it, is rapidly and completely deprived of its water. For this purpose the chloride need not be absolutely pure: it should not be fused, but merely dried, as the unfused is more porous, and consequently offers a larger amount of surface to any gas passed over it.

Chloride of Barium (BaCl+2Aq).

Chloride of barium sometimes contains traces of iron and lime. It should not be discoloured by hydrosulphate of ammonia, and, after being treated with a slight excess of sulphuric acid, and filtered, the clear solution should leave no fixed residue when evaporated on platinum foil; because the whole of the baryta is separated by the sulphuric acid, and any other fixed matter must be some impurity.

It is used chiefly for the purpose of testing for acids, especially sulphuric, with which it forms the insoluble sulphate of baryta. For use, one part of the salt may be dissolved in ten parts of water.

Nitrate of Baryta (BaO,NO₅).

Nitrate of baryta is liable to the same impurities as chloride of barium, and they may be detected in the same way. It should also be free from any chloride, which may be known by adding nitrate of silver. Its uses are the same as those of chloride of barium, for which it is occasionally substituted in cases when the addition of the chloride would interfere with the subsequent stages of an analysis, as

when we have to test for chlorides in the same solution. For use, it may be dissolved in ten parts of water.

Perchloride of Iron (Fe_2Cl_3).

This salt is liable to contain a little free acid, and traces of the protochloride. The free acid is detected in the manner described; and if any protosalt of iron is present, the solution gives a blue colour with ferridcyanide of potassium. It is used as a test for some of the organic acids, and is also sometimes useful in the determination of phosphoric acid. It may be dissolved in five parts of water.

Nitrate of Cobalt ($\text{CoO}, \text{NO}_3 + 6\text{Aq}$).

This reagent is used chiefly for the detection of alumina, zinc, magnesia, and some other substances, by means of the blowpipe. The solution employed for this purpose, may contain one part of the salt dissolved in ten of water.

Sulphate of Copper ($\text{CuO}, \text{SO}_3 + 5\text{Aq}$).

This salt is occasionally used as a test for arsenic, and for other purposes: it may be dissolved in ten parts of water. The *ammonio-sulphate of copper*, which is also used in testing for arsenic, is prepared by adding ammonia to the solution of sulphate of copper, until the precipitate at first formed is nearly all redissolved, when the solution is filtered, and kept for use.

Acetate of Lead ($\text{PbO}, \text{C}_4\text{H}_3\text{O}_3 + 3\text{Aq}$).

Acetate of lead is used as a test for several acids, which form with oxide of lead insoluble salts. For testing, one part of the salt may be dissolved in ten parts of water.

Subacetate of Lead ($3\text{PbO}, \text{C}_4\text{H}_3\text{O}_3$).

The subacetate is prepared by boiling together equal weights of the neutral acetate and protoxide of lead in water, and filtering the solution, which must be kept in a well-stoppered bottle, as it is easily decomposed when in contact with the air, owing to the strong affinity of

the oxide of lead for carbonic acid. Both this and the neutral acetate are used in testing for hydrosulphuric acid, and for some of the other acids, especially carbonic.

Nitrate of Silver (AgO, NO_5).

This reagent is sometimes adulterated with nitrate of potash, and occasionally contains traces of copper and lead. When precipitated by a slight excess of hydrochloric acid, the filtered solution ought to leave no fixed residue when evaporated on platinum foil, as the whole of the silver would be thrown down, and any impurity would remain in solution. Copper is detected by adding ammonia in excess to the solution, when it will give the liquid a blue tinge. Nitrate of silver is used chiefly as a test for chlorine (chlorides and hydrochloric acid), and also for phosphoric, and some of the other acids. For use as a reagent, one part of the salt may be dissolved in twenty parts of water.

The *ammonio-nitrate of silver*, used as a test for arsenic, is prepared by adding ammonia to a solution of the nitrate, until the precipitate at first thrown down is nearly all redissolved, and filtering from the undissolved oxide.

Perchloride of Mercury (HgCl_2).

This is occasionally employed as a test for hydriodic and some other acids, and also for some kinds of organic matter: for this purpose it may be dissolved in twenty parts of water.

Protochloride of Tin (SnCl).

Protochloride of tin is prepared by boiling metallic tin in strong hydrochloric acid, care being taken that a portion of the metal remains undissolved, as otherwise a little perchloride might be formed; the solution is then filtered, acidified with a few drops of hydrochloric acid, and diluted with about four times its bulk of water. A few fragments of metallic tin should be kept in the solution, in order to prevent the formation of any perchloride.

Protochloride of tin is employed chiefly as a test for gold and mercury, and also as a deoxidizing agent, for which purpose it is well adapted on account of its strong tendency to combine with oxygen or chlorine.

It occasionally contains traces of lead and iron, which may be detected by adding hydrosulphate of ammonia in excess to the solution, when, if pure, the precipitate is wholly redissolved, but if either of those metals is present, a black residue is left, since their sulphides are insoluble in the hydrosulphate.

Perchloride of Gold (AuCl_3).

This reagent is used almost exclusively as a test for the protosalts of tin, so that a very small quantity will be found sufficient for the purposes of testing. One part of the salt may be dissolved in thirty parts of water.

Bichloride of Platinum (PtCl_2).

Bichloride of platinum is employed only as a test for potash, soda, and ammonia: it may be dissolved in about ten parts of alcohol.

Sulphate of Indigo.

This substance may be prepared in solution, by dissolving a little indigo in strong sulphuric acid, and diluting the acid solution with water, so as to form a pale blue liquid. It is used chiefly as a test for nitric acid and chlorine, by which it is decomposed, and its colour discharged.

Solution of Starch ($\text{C}_{12}\text{H}_{10}\text{O}_{10}$).

This is made by gently boiling starch with water. It is employed as a test for iodine, for which purpose small pieces of thread or paper may be steeped in the solution, dried, and kept for use.

Black Flux.

Black flux is an intimate mixture of carbonate of potash and finely divided charcoal, and is prepared by deflagrating in an iron spoon or crucible, a mixture of two parts of bitartrate of potash and one of nitre. It is used as a reducing flux in blowpipe experiments.

Distilled Water (HO).

Pure distilled water is prepared by carefully distilling any of the common kinds of water either in a still or retort, rejecting the first and last portions. For many purposes, rain water, when collected at a distance from towns or manufactories, and boiled and filtered, will be found sufficiently pure; but, in analytical experiments, distilled water ought always to be used.

Before taking it into use, it should be tested with the following reagents:—

- (a) Litmus and turmeric paper, for free acids and alkalies.
- (b) Chloride of barium for sulphates.
- (c) Nitrate of silver for chlorides. The mixture shortly becomes dark-coloured, especially if organic matter is present.
- (d) Oxalate of ammonia for lime.
- (e) Lime water for carbonic acid.
- (f) Hydrosulphate of ammonia for any metals of the third or fourth class.
- (g) When heated on platinum foil, it should leave no trace of solid residue.

Distilled water is used chiefly as a solvent, and for washing precipitates, besides many other purposes to which it is constantly applied.

Alcohol (C₄H₅O, HO).

The alcohol commonly used in chemical experiments should have a specific gravity of about 0.83, except in cases where absolute alcohol is required, when it should be 0.796. When evaporated on platinum foil, it should leave no residue, and should not change the colour of litmus paper. It is used chiefly as a solvent, and for the purpose of facilitating the precipitation of substances which are less soluble in it than in water.

TABLE I.

Showing the Quantity of Oil of Vitriol (HO, SO_3) of sp. gr. 1·8485, and of Anhydrous Acid (SO_3) in 100 Parts of Dilute Sulphuric Acid, of different Specific Gravities (Ure).

Liquid Acid.	Sp. Gr.	Dry Acid.	Liquid Acid.	Sp. Gr.	Dry Acid.
100	1·8485	81·54	59	1·4760	48·11
99	1·8475	80·72	58	1·4660	47·29
98	1·8460	79·90	57	1·4560	46·48
97	1·8439	79·09	56	1·4460	45·66
96	1·8410	78·28	55	1·4360	44·85
95	1·8376	77·46	54	1·4265	44·03
94	1·8336	76·65	53	1·4170	43·22
93	1·8290	75·83	52	1·4073	42·40
92	1·8233	75·02	51	1·3977	41·58
91	1·8179	74·20	50	1·3884	40·77
90	1·8115	73·39	49	1·3788	39·95
89	1·8043	72·57	48	1·3697	39·14
88	1·7962	71·75	47	1·3612	38·32
87	1·7870	70·94	46	1·3530	37·51
86	1·7774	70·12	45	1·3440	36·69
85	1·7673	69·31	44	1·3345	35·88
84	1·7570	68·49	43	1·3255	35·06
83	1·7465	67·68	42	1·3165	34·25
82	1·7360	66·86	41	1·3080	33·43
81	1·7245	66·05	40	1·2999	32·61
80	1·7120	65·23	39	1·2913	31·80
79	1·6993	64·42	38	1·2826	30·98
78	1·6870	63·60	37	1·2740	30·17
77	1·6750	62·78	36	1·2654	29·35
76	1·6630	61·97	35	1·2572	28·54
75	1·6520	61·15	34	1·2490	27·72
74	1·6415	60·34	33	1·2409	26·91
73	1·6321	59·52	32	1·2334	26·09
72	1·6204	58·71	31	1·2260	25·28
71	1·6090	57·89	30	1·2184	24·46
70	1·5975	57·08	29	1·2108	23·65
69	1·5868	56·26	28	1·2032	22·83
68	1·5760	55·45	27	1·1956	22·01
67	1·5648	54·63	26	1·1876	21·20
66	1·5503	53·82	25	1·1792	20·38
65	1·5390	53·00	24	1·1706	19·57
64	1·5280	52·18	23	1·1626	18·75
63	1·5170	51·37	22	1·1549	17·94
62	1·5066	50·55	21	1·1480	17·12
61	1·4960	49·74	20	1·1410	16·31
60	1·4860	48·92	19	1·1330	15·49

Liquid Acid.	Sp. Gr.	Dry Acid.	Liquid Acid.	Sp. Gr.	Dry Acid.
18	1·1246	14·68	9	1·0614	7·34
17	1·1165	13·86	8	1·0544	6·52
16	1·1090	13·05	7	1·0477	5·71
15	1·1019	12·23	6	1·0405	4·89
14	1·0953	11·41	5	1·0336	4·08
13	1·0887	10·60	4	1·0268	3·26
12	1·0809	9·78	3	1·0206	2·446
11	1·0743	8·97	2	1·0140	1·63
10	1·0682	8·15	1	1·0074	0·8154

TABLE II.

Showing the Quantity of Real or Anhydrous Nitric Acid (NO₃) in 100 Parts of Liquid Acid, of different Specific Gravities (Ure).

Specific Gravity.	Real acid in 100 parts of the Liquid.	Specific Gravity.	Real acid in 100 parts of the Liquid.	Specific Gravity.	Real acid in 100 parts of the Liquid.
1·5000	79·700	1·4107	58·181	1·2705	36·662
1·4980	78·903	1·4065	57·384	1·2644	35·865
1·4960	78·106	1·4023	56·587	1·2583	35·068
1·4940	77·309	1·3978	55·790	1·2523	34·271
1·4910	76·512	1·3945	54·993	1·2462	33·474
1·4880	75·715	1·3882	54·196	1·2402	32·677
1·4850	74·918	1·3833	53·399	1·2341	31·880
1·4820	74·121	1·3783	52·602	1·2277	31·083
1·4790	73·324	1·3732	51·805	1·2212	30·286
1·4760	72·527	1·3681	51·068	1·2148	29·489
1·4730	71·730	1·3630	50·211	1·2084	28·692
1·4700	70·933	1·3579	49·414	1·2019	27·895
1·4670	70·136	1·3529	48·617	1·1958	27·098
1·4640	69·339	1·3477	47·820	1·1895	26·301
1·4600	68·542	1·3427	47·023	1·1833	25·504
1·4570	67·745	1·3376	46·226	1·1770	24·707
1·4530	66·948	1·3323	45·429	1·1709	23·910
1·4500	66·155	1·3270	44·632	1·1648	23·113
1·4460	65·354	1·3216	43·835	1·1587	22·316
1·4424	64·557	1·3163	43·038	1·1526	21·519
1·4385	63·760	1·3110	42·241	1·1465	20·722
1·4346	62·963	1·3056	41·444	1·1403	19·925
1·4306	62·166	1·3001	40·647	1·1345	19·128
1·4269	61·369	1·2947	39·850	1·1286	18·331
1·4228	60·572	1·2887	39·053	1·1227	17·534
1·4189	59·775	1·2826	38·256	1·1168	16·737
1·4147	58·978	1·2765	37·459	1·1109	15·940

Specific Gravity.	Real acid in 100 parts of the Liquid.	Specific Gravity.	Real acid in 100 parts of the Liquid.	Specific Gravity.	Real acid in 100 parts of the Liquid.
1·1051	15·143	1·0651	9·564	1·0320	4·782
1·0993	14·346	1·0595	8·767	1·0267	3·985
1·0935	13·549	1·0540	7·970	1·0212	3·188
1·0878	12·752	1·0485	7·173	1·0159	2·391
1·0821	11·955	1·0430	6·376	1·0106	1·594
1·0764	11·158	1·0375	5·579	1·0053	0·797
1·0708	10·361				

TABLE III.

Showing the Quantity of Anhydrous Hydrochloric Acid (HCl) in the Liquid Acid of different Specific Gravities (Ure).

Acid of 120 in 100.	Specific Gravity.	Chlorine.	Hydro-chloric Gas.	Acid of 120 in 100.	Specific Gravity.	Chlorine.	Hydro-chloric Gas.
100	1·2000	39·675	40·777	72	1·1452	28·567	29·359
99	1·1982	39·278	40·369	71	1·1431	28·171	28·951
98	1·1964	38·882	39·961	70	1·1410	27·772	28·544
97	1·1946	38·485	39·554	69	1·1389	27·376	28·136
96	1·1928	38·089	39·146	68	1·1369	26·979	27·728
95	1·1910	37·692	38·738	67	1·1349	26·583	27·321
94	1·1893	37·296	38·330	66	1·1328	26·186	26·913
93	1·1875	36·900	37·923	65	1·1308	25·789	26·505
92	1·1857	36·503	37·516	64	1·1287	25·392	26·098
91	1·1846	36·107	37·108	63	1·1267	24·996	25·690
90	1·1822	35·707	36·700	62	1·1247	24·599	25·282
89	1·1802	35·310	36·292	61	1·1226	24·202	24·874
88	1·1782	34·913	35·884	60	1·1206	23·805	24·466
87	1·1762	34·517	35·476	59	1·1185	23·408	24·058
86	1·1741	34·121	35·068	58	1·1164	23·012	23·650
85	1·1721	33·724	34·660	57	1·1143	22·615	23·242
84	1·1701	33·328	34·252	56	1·1123	22·218	22·834
83	1·1681	32·931	33·845	55	1·1102	21·822	22·426
82	1·1661	32·535	33·437	54	1·1082	21·425	22·019
81	1·1641	32·136	33·029	53	1·1061	21·028	21·611
80	1·1620	31·743	32·621	52	1·1041	20·632	21·203
79	1·1599	31·343	32·213	51	1·1020	20·235	20·796
78	1·1578	30·946	31·805	50	1·1000	19·837	20·388
77	1·1557	30·550	31·398	49	1·0980	19·440	19·980
76	1·1536	30·153	30·990	48	1·0960	19·044	19·572
75	1·1515	29·757	30·582	47	1·0939	18·647	19·165
74	1·1494	29·361	30·174	46	1·0919	18·250	18·757
73	1·1473	28·964	29·767	45	1·0899	17·854	18·349

Acid of 120 in 100.	Specific Gravity.	Chlorine.	Hydro- chloric Gas.	Acid or 120 in 100.	Specific Gravity.	Chlorine.	Hydro- chloric Gas.
44	1·0879	17·457	17·941	22	1·0437	8·729	8·971
43	1·0859	17·060	17·534	21	1·0417	8·332	8·563
42	1·0838	16·664	17·126	20	1·0397	7·935	8·155
41	1·0818	16·267	16·718	19	1·0377	7·538	7·747
40	1·0798	15·870	16·310	18	1·0357	7·141	7·340
39	1·0778	15·474	15·902	17	1·0337	6·745	6·932
38	1·0758	15·077	15·494	16	1·0318	6·348	6·524
37	1·0738	14·680	15·087	15	1·0298	5·951	6·116
36	1·0718	14·284	14·679	14	1·0279	5·554	5·709
35	1·0697	13·887	14·271	13	1·0259	5·158	5·301
34	1·0677	13·490	13·863	12	1·0239	4·762	4·893
33	1·0657	13·094	13·456	11	1·0220	4·265	4·486
32	1·0637	12·597	13·049	10	1·0200	3·998	4·078
31	1·0617	12·300	12·641	9	1·0180	3·571	3·670
30	1·0597	11·903	12·233	8	1·0160	3·174	3·262
29	1·0577	11·506	11·825	7	1·0140	2·778	2·854
28	1·0557	11·109	11·418	6	1·0120	2·381	2·447
27	1·0537	10·712	11·010	5	1·0110	1·984	2·039
26	1·0517	10·316	10·602	4	1·0080	1·588	1·631
25	1·0497	9·919	10·194	3	1·0060	1·191	1·224
24	1·0477	9·522	9·786	2	1·0040	0·795	0·816
23	1·0457	9·126	9·379	1	1·0020	03·97	0·408

TABLE IV.

Proportion of Hydrated Acetic Acid ($\text{HO}, \text{C}_4\text{H}_3\text{O}_3$) in 100 parts of acid at various densities.

Hydr. Acet. Ac. in 100 parts.	Density.	Hydr. Acet. Ac. in 100 parts.	Density.	Hydr. Acet. Ac. in 100 parts.	Density.
100	1063·5	88	1073·0	76	1073·0
99	1065·5	87	1073·0	75	1072·0
98	1067·0	86	1073·0	74	1072·0
97	1068·0	85	1073·0	73	1072·0
96	1069·0	84	1073·0	72	1071·0
95	1070·0	83	1073·0	71	1071·0
94	1070·6	82	1073·0	70	1070
93	1070·8	81	1073·2	69	1070
92	1071·6	80	1073·5	68	1070
91	1072·1	79	1073·5	67	1069
90	1073·0	78	1073·2	66	1069
89	1073·0	77	1073·2	65	1068

Hydr. Acet. Ac. in 100 parts.	Density.	Hydr. Acet. Ac. in 100 parts.	Density.	Hydr. Acet. Ac. in 100 parts.	Density.
64	1068	42	1052	20	1027
63	1068	41	1051·5	19	1026
62	1067	40	1051·3	18	1025
61	1067	39	1050	17	1024
60	1067	38	1049	16	1023
59	1066	37	1048	15	1022
58	1066	36	1047	14	1020
57	1065	35	1046	13	1018
56	1064	34	1045	12	1017
55	1064	33	1044	11	1016
54	1063	32	1042·4	10	1015
53	1063	31	1041	9	1013
52	1062	30	1040	8	1012
51	1061	29	1039	7	1010·7
50	1060	28	1038	6	1008·5
49	1059	27	1036	5	1006
48	1058	26	1035	4	1005
47	1056	25	1034	3	1004
46	1055	24	1033	2	1002
45	1055	23	1032	1	1001
44	1054	22	1031	0	1000
43	1053	21	1029		

TABLE V.

Showing the Quantity of Anhydrous Potash (KO) in Solutions of different Specific Gravities (Dalton).

Specific Gravity.	Potash per cent.	Boiling Point.	Specific Gravity.	Potash per cent.	Boiling Point.
1·63	51·2	329°	1·33	26·3	229°
1·60	46·7	290	1·28	23·4	224
1·52	42·9	276	1·23	19·5	220
1·47	39·6	265	1·19	16·2	218
1·44	36·8	255	1·15	13·	215
1·42	34·4	246	1·11	9·5	214
1·39	32·4	240	1·06	4·7	213
1·36	29·4	234			

TABLE VI.

Showing the Quantity of Anhydrous Soda (NaO) in Solutions of different Specific Gravities (Dalton).

Specific Gravity.	Soda per cent.	Boiling Point.	Specific Gravity.	Soda per cent.	Boiling Point.
2.00	77.8	—°?	1.40	29.0	242°
1.85	63.6	600	1.36	26.0	235
1.72	53.8	400	1.32	23.0	228
1.63	46.6	300	1.29	19.0	224
1.56	41.2	280	1.23	16.0	220
1.50	36.8	265	1.18	13.0	217
1.47	34.0	255	1.12	9.0	214
1.44	31.0	248	1.06	4.7	213

TABLE VII.

Showing the Quantity of Ammoniacal Gas (NH₃) in Aqueous Solutions of different Specific Gravities (Dalton).

Specific Gravity.	Grains of Ammonia in 100 grains of the liquid.	Boiling Points.	Volumes of Gas in one volume of the liquid.
.850	35.3	26°	494
.860	32.6	38	456
.870	29.9	50	419
.880	27.3	62	382
.890	24.7	74	346
.900	22.2	86	311
.910	19.8	98	277
.920	17.4	110	244
.930	15.1	122	211
.940	12.8	134	180
.950	10.5	146	147
.960	8.3	158	116
.970	6.2	173	87
.980	4.1	187	58
.990	2.0	196	28

TABLE VIII.

Showing the Quantity of Absolute Alcohol (C_4H_9O, HO) contained in Diluted Alcohol of Different Specific Gravities (Löwitz).

100 parts.		Specific Gravity.		100 parts.		Specific Gravity.	
Alc.	Wat.	At 68°.	At 60°.	Alc.	Wat.	At 68°.	At 60°.
100	0	0.791	0.796	59	41	0.894	0.898
99	1	0.794	0.798	58	42	0.896	0.900
98	2	0.797	0.801	57	43	0.899	0.902
97	3	0.800	0.804	56	44	0.901	0.904
96	4	0.803	0.807	55	45	0.903	0.906
95	5	0.805	0.809	54	46	0.905	0.908
94	6	0.808	0.812	53	47	0.907	0.910
93	7	0.811	0.815	52	48	0.909	0.912
92	8	0.813	0.817	51	49	0.912	0.915
91	9	0.816	0.820	50	50	0.914	0.917
90	10	0.818	0.822	49	51	0.917	0.920
89	11	0.821	0.825	48	52	0.919	0.922
88	12	0.823	0.827	47	53	0.921	0.924
87	13	0.826	0.830	46	54	0.923	0.926
86	14	0.828	0.832	45	55	0.925	0.928
85	15	0.831	0.835	44	56	0.927	0.930
84	16	0.834	0.838	43	57	0.930	0.933
83	17	0.836	0.840	42	58	0.932	0.935
82	18	0.839	0.843	41	59	0.934	0.937
81	19	0.842	0.846	40	60	0.936	0.939
80	20	0.844	0.848	39	61	0.938	0.941
79	21	0.847	0.851	38	62	0.940	0.943
78	22	0.849	0.853	37	63	0.942	0.945
77	23	0.851	0.855	36	64	0.944	0.947
76	24	0.853	0.857	35	65	0.946	0.949
75	25	0.856	0.860	34	66	0.948	0.951
74	26	0.859	0.863	33	67	0.950	0.953
73	27	0.861	0.865	32	68	0.952	0.955
72	28	0.863	0.867	31	69	0.954	0.957
71	29	0.866	0.870	30	70	0.956	0.958
70	30	0.868	0.872	29	71	0.957	0.960
69	31	0.870	0.874	28	72	0.959	0.962
68	32	0.872	0.875	27	73	0.961	0.963
67	33	0.875	0.879	26	74	0.963	0.965
66	34	0.877	0.881	25	75	0.965	0.967
65	35	0.880	0.883	24	76	0.966	0.968
64	36	0.882	0.886	23	77	0.968	0.970
63	37	0.885	0.889	22	78	0.970	0.972
62	38	0.887	0.891	21	79	0.971	0.973
61	39	0.889	0.893	20	80	0.973	0.974
60	40	0.892	0.896	19	81	0.974	0.975

100 parts.		Specific Gravity.		100 parts.		Specific Gravity.	
Alc.	Wat.	At 68°.	At 60°.	Alc.	Wat.	At 68°.	At 60°.
18	82	0·976	0·977	8	92	0·989	0·990
17	83	0·977	0·978	7	93	0·991	0·991
16	84	0·978	0·979	6	94	0·992	0·992
15	85	0·980	0·981	5	95	0·994	
14	86	0·981	0·982	4	96	0·995	
13	87	0·983	0·984	3	97	0·997	
12	88	0·985	0·986	2	98	0·998	
11	89	0·986	0·987	1	99	0·999	
10	90	0·987	0·988	0	100	1·000	
9	91	0·988	0·989				

INDEX.

A.

Acetic acid as a test, 548.
 extracts, 310.
 solutions, 279.
 Acetate of lead as a test, 557.
 Acidimetry, 384.
 Acidimeter, Baumé's, 63.
 Adapter, 321.
 Aids to dispensing, 466.
 Air-furnace, or wind-furnace, 80.
 Air-tight filter, 199.
 Alarum, laboratory, 123.
 Alcohol for analysis, 560.
 as a menstruum, 337.
 Alcoholic and ethereal solutions for extracts,
 and for tinctures, 262.
 Alcohometer, Gay-Lussac's, 65.
 Alcoolatures, or preserved juices, 278.
 Alkalimeter, 383.
 Alkalimetry, 382.
 Alsop's minim-meter, 46.
 Ammonia as a test, 549.
 apparatus for generating, 398.
 Ammonio-nitrate of silver, 558.
 sulphate of copper, 557.
 Antimoniate of potash as a test, 554.
 Anhydrous phosphoric acid, apparatus for
 preparing, 372.
 Apparatus, Beindorf's, 107, 111-116.
 for bleaching sponge, 397.
 for destructive distillation, 367.
 for displacement, 259, 260, 264, 270, 272.
 Gilbertson's, 270.
 carbonic acid, 387, 388, 391.
 for distillation, 114, 316, 322, 323, 328, 339.
 drug grinding, 152-158.
 Gadda's condensing, 114.
 for generating ammonia, 398.
 chlorine, 396.
 hydrogen, 393.
 Henry's, for calomel, 364.
 for lixiviating crude soda, 239.
 Mohr's, for digesting with ether, 246.
 for benzoic acid, 361.
 for making ethereal tinctures, 264.
 for powdering drugs, 151.
 for preparing heavy carbonate of mag-
 nesia, 380.
 lead plaster, 420.
 phosphoric acid, 372.
 spread plasters, 524.
 extracts in vacuo, 294.
 for reduction by hydrogen, 394.
 for reducing iron by hydrogen, 395.
 spreading plasters, 527, 528.
 sulphuretted hydrogen, 393, 548.
 sifting, 160.
 spontaneous evaporation, 303.
 steam, 107.
 for laboratory, 135.
 stirring extracts, 121.
 subliming benzoic acid, 361.
 calomel, 364, 365.

Apparatus, Smith's displacement, 260.
 Soubeiran's ether digesting, 246.
 for taking specific gravities, 57.
 vacuum, 297.
 Wohler's, for prussic acid, 342.
 Woulf's, 401, 402, 404.
 Application of heat in distillation, 324.
 Aqueous extracts, 248.
 Areometers or hydrometers, 61.
 Arnott's, Dr. ventilating valve, 25.
 Arrangement for continuous displacement,
 272.
 filtration, 203.
 for cutting glass, 436.
 Arrangements of the dispensing counter,
 29, 30.
 of shop, 18.
 for distillation, 328.
 for gas-lighting and ventilation, 22.
 general, 17.
 for heating the shop, 22.
 for ventilating the shop, 24.
 Arsenic, sublimation of metallic, 366.

B.

Bags, dusting, 150.
 press, 233.
 Balance-case for apothecaries, 45.
 Balance, method of holding the, 48.
 Bath, sand, 112, 325.
 steam, 291.
 water, 290.
 Baumé's acidometer, 63.
 hydrometers, 63.
 spirit hydrometer, 64.
 Beer-knot, 432.
 Beindorf's apparatus, 107, 111, 116.
 condenser, 113.
 decoction press, 478.
 Bellows for blowpipe, 442.
 double, 84.
 Bending of glass tubes, 439-441.
 Bent tubes, 441.
 Benzoic acid, sublimation of, 361.
 Benzoated lard, 417.
 Bichloride of platinum as a test, 559.
 Binding knot, 430.
 Black flux, 559.
 Black's blowpipe, 101.
 Blast-furnace, 83.
 common, 88, 90.
 Blistering tissue, 531.
 Blower, centrifugal, 89, 306.
 Blowing bulbs on tubes, 446.
 machine, 89, 306.
 Blowpipe, Dr. Black's, 101.
 flame, 102.
 gas, 100, 447.
 glass-blowers, 442.
 mode of using the, 102.
 Pepys's, 101.
 syringe, 101.
 water, 442.

Blowpipe, water, mode of using, 443.
Wollaston's, 101.

Blowpipes, 100.

Boiler of Beindorf's apparatus, 108.
gauge, 110.

steam, 129, 130, 132.

Borax as a reagent, 555.

Boring and drilling glass, 438.

Bottle, specific gravity, 60.
stoop, 33.

Bottles, stoppering of, 423.

wash-, 208.

Woulf's, 401.

Box, granulating, 171.

Boxes, store-room, 35.

Bramah's hydraulic press, 226, 229, 234.

Bromine, pipettes for decanting, 186.

Bucket, specific gravity, 59.

Bulbs, blowing, on tubes, 446.

Bumping in distillation explained, 330.

Burners, gas, 95.

Burnt plaster, 422.

C.

Calomel, sublimation of, 362.

Calcination, process of, 368.

of magnesia, 369.

Canisters, japanned, for herbs, 28.

Capped retorts, 322.

Capping knot, 429.

Capsule mould, 510.

Capsules, 510.

filling of, 512.

membrane, 513.

preparation of, 511.

Carbonate of ammonia as a test, 550.

of potash as a reagent, 552.

of soda as a reagent, 554.

Carbonic acid apparatus, 387, 388, 391.

generation and absorption of, 390.

Carbonization, 367.

Cartier's hydrometer, 64.

Casting of zinc, potash, and lunar caustic, 460.

Cataplasms, 515.

Cellar, store, 36.

Centrifugal blower, 89, 306.

Cerate, simple, 412.

Cerates, 412.

and ointments, 412.

Cerated cloth, 530.

Champagne knot, 433.

Charcoal, animal, 202, 210.

filter for decolorizing, 211.

Chinese cutting trough, 145.

Chloride of calcium as a test, 556.

of barium as a test, 556.

of gold, per-, as a test, 559.

of iron, per-, as a test, 557.

of mercury, per-, as a test, 558.

Chlorine gas, bleaching with, 397.

generation and absorption of, 396.

water, preparation of, 397.

Chloroform inhalers, 539.

Chopping trough, 140.

Chromate of potassa as a test, 553.

Circulatory displacement, 238.

Clarification, 208.

of syrups, 280.

Classification of extracts, 308.

Closed operating chamber or closet, 461.

Closet, drying, 300, 305.

Coarse comminution of vegetable substances, 140.

Coating glass with copper, 455.

vessels with silver, 339.

Cohesion and adhesion in oil of vitriol, forces of, 332.

of water, forces of, 333.

Coke, 76.

Collyriums, 514.

Comminution, coarse, of vegetable substances, 140.

Common blast-furnace, 88, 90.

portable furnace, 92, 94.

worm tub, 113.

Condenser, Beindorf's, 109.

common, 114.

ether, 358, 359.

Gadda's, 114.

Kolle's, 114.

Liebig's, 323, 324.

Mitscherlich's, 115.

Mohr's spirit, 118.

stoneware, 347.

Conical filter-bag, 190.

mould for levigated chalk, 157, 173.

Connecting and luting of apparatus, 450.

Connecters, gum-elastic, 450.

Conserves, preparation of, 494.

Consistence of extracts, 310.

Continuous displacement, 272.

filtration, 203.

Contusion, 146.

Cooling or condensing tub, 113.

Cooper's lamp-furnace, 99.

Cork borers, 351, 352.

squeezers, 31, 33.

Corrosive sublimate, apparatus for, 364.

Counter, dispensing, 28-30.

Court-plaster, 530.

Cover for mortar, 149.

Covering of pills with gelatin, 509.

Cradle-knife, 145.

Crucible furnace, 85.

Hessian, 78.

iron, 78.

platinum, 78.

porcelain, 78.

Crucibles, 78.

management of, 79.

Crushing of herbs, 307.

Crystallization, 373.

by sublimation, 373.

by fusion, 373.

from solutions, 374.

intermediate, 377.

Cucurbit and head, 108.

and false bottom, 108, 350.

Cup, saccharometer-, 281.

Cutting, drilling, and bending of glass, 435.

Cutting knife, 141.

knives, root, 35.

Mohr's self-supplying, 144.

trough, Chinese, 145.

D.

Decantation and washing, 174.

over a greased rim, 176.

with a guiding rod, 175.

Decoction press, Beindorf's, 473.

process of, 247.

saucepan, 471.

Decoctions and infusions, 470.

Decoloration, 210.

of fixed oils, 411.

of resins, 212.

of syrups, 282.

- Deflagration, 369.
 Desiccation of bottles, flasks, etc., 428.
 Destructive distillation, 367.
 Determination of specific gravities, 55.
 Dicas's hydrometer, 67.
 Digester, Chevreul's, 247.
 Papin's, 368.
 Digestion, 246.
 and infusion, 118.
 Dispensary or shop, 17.
 Dispensing, aids to, 466.
 counter, 28.
 of medicines, 463.
 Displacement apparatus, 259, 260, 264, 270, 272.
 continuous, 272.
 Gilbertson's, 270.
 Smith's, 260.
 process of, 247, 252, 268.
 Displacers, glass, 272.
 for volatile liquids, 270, 272.
 Distillation, 115, 314.
 apparatus for, 114, 316, 322, 323, 338, 339.
 arrangements for, 317, 328.
 dry or destructive, 367.
 of essential oils, 348.
 in glass vessels, 329.
 of hydrocyanic acid, 341.
 of oil of bitter almonds, 353.
 black mustard, 353.
 vitriol, 336, 337.
 process of, 316.
 of spirits, 118.
 Distilled waters, 348, 560.
 Division of shop into compartments, 27.
 Donovan's filter, 201.
 Double bellows, 84.
 screw or horizontal press, 215.
 Draughts, preparation of, 486.
 Drawing out glass tubes, 443.
 Drill for boring glass, 439.
 Drilling or boring glass, 438.
 Drug grinding, apparatus for, 158.
 mill, 307.
 Swift's, 152.
 Drugs, pulverization of, 146.
 apparatus for the, 151.
 Dry or destructive distillation, 367.
 Drying-closet, 300.
 portable, 305.
 room or loft, 36.
 Dusting bags, 150.
- E.
- Effects of temperature, 106.
 Elaëometer, 69.
 Electuaries, preparation of, 494.
 Elutriation, 173.
 Embrocations, 514.
 Emulsions, preparation of, 488.
 Enemas, 514.
 Escape for noxious gases, 405.
 Essence of ginger, process for, 273.
 Essential oils, distillation of, 348.
 preservation and rectification of, 356.
 solution of, 339.
 Ether condenser, 358, 359.
 inhalers, 536, 537.
 rectification of, 357.
 Ethereal extracts and tinctures, 262.
 tinctures, apparatus for making, 270.
 Evaporating pans, 109.
 Evaporation over the naked fire, 289.
- Evaporation, process of, 287.
 spontaneous, 298.
 apparatus for, 303.
 of solutions for extracts, 288.
 surface, 120.
 in vacuo, 293.
 vessels for, 288.
 by water-bath or steam-bath, 290.
 of water, rates of, at different temperatures, 292.
 Extraction of fixed stoppers, 424.
 Extracts, apparatus for preparing, in vacuo, 294.
 for stirring, 120.
 acetic, 310.
 aqueous, 248.
 alcoholic, 309.
 consistence of, 310.
 ethereal, 310.
 fluid, 311.
 oleo-resinous, 310.
 preparation of, 248, 262, 288, 308.
 and tinctures, solutions for, 262.
 preservation of, 311.
 Extemporaneous pharmacy, 463-497.
- F.
- Fahrenheit's hydrometer, 62.
 Faraday's gas-lamp, 24.
 Ferridcyanide of potassium as a test, 554.
 Ferrocyanide of potassium as a test, 553.
 Filling capsules, 512.
 Filter, air-tight, 199.
 bag, conical, 190.
 charcoal, 211.
 Donovan's, 201.
 frame, 191.
 pattern, 196.
 plain, 195.
 modification of, 196.
 plated, 197, 198.
 support, 195.
 Taylor's, 192.
 vacuum, 193.
 Filtering, hot, 200.
 media, 187.
 Filters, construction of, 190.
 of inorganic materials, 201.
 paper, 194.
 Filtration, 187.
 continuous, 203.
 Fixed oils, preparation of, by boiling, 409.
 expression, 408.
 solution, 410.
 stoppers, modes of removing, 424.
 Flame-furnace, 91.
 Flasks, 325-329.
 coated with copper, 325.
 coating of, with copper, 456.
 desiccation of, 428.
 distillation with, 328, 339.
 Florentine receiver, 351.
 Fluid extracts, 311.
 Fluxes, 370.
 Forces of cohesion and adhesion in oil of vitriol, 332.
 in water, 333.
 Fox, the furnace, 112.
 Frame filter, 191.
 Fuel for furnaces, 76.
 Fumes, inhalation of, 540.
 Funnel, porcelain, 195.
 retort, 318.
 steam, 109, 358.

Funnel-tube, 318.
 water-bath, 200.
 well-formed, 191.

Furnace and appendages, portable, 344.
 air or wind, 81.
 blast, 83.
 common blast, 88.
 portable, 92-94.
 for calcining magnesia, 369.
 crucible, 85.
 flame or reverberatory, 91.
 gas, 96, 127.
 Rickets's, 20.
 Hood, 124, 406.
 mixed gas, 20.
 operations, 75.
 and sand-pot for distillation, 343.
 Seftstroem's, 86.

G.

Gadda's condensing apparatus, 114.
 Galactometer, 70.
 Gargles, 514.

Gas and alcohol lamps, 94.
 blowpipe, 101, 447.
 burners, 95.
 carbonic acid, generation and absorption of, 390.
 chlorine, generation and absorption of, 396.
 flame, solid, 95, 440.
 furnace, Rickets's, 20.
 furnaces, 20, 96, 127, 325.
 lamp, Faraday's, 24.
 lighting and ventilation, 22.
 stove, 19.

Gases, generation and absorption of, 386.
 inhalation of, 532.

Gay-Lussac's alcoholmeter, 65.
 holder, 326.

Gelatin, coating of pills with, 509.

General arrangements, 17.

Generation and absorption of gases, 386.

Gilbertson's displacement apparatus, 270.

Gilding and silvering pills, 568.

Ginger, process for essence of, 273.

Glass-blower's blowpipe, 442.

Glass, boring and drilling of, 438.
 bottles, stoppering of, 424.
 cone for taking specific gravities, 70.
 cutting, with a charcoal point, 437.
 displacers, 272.
 drill for boring, 439.
 syringe, 48.
 tubes, bending of, 441.
 drawing out of, 443.
 joining or cementing, 445.
 sealing of, 443, 446.
 hermetically, 446.
 tubes, widening of, 445.
 graduating, 449.
 vessels, coating of, with silver, 339.
 graduation of, 448.

Glasses, precipitating, 378.

Glycerin, preparation of, 421.

Gout paper, 531.

Granulating box, 171.

Granulation of gold and silver, 172.
 iron, 172.
 metals, 170.
 salts, 376.
 tin, 171.
 zinc, 170.

Gravimeter, 63.

Gruff, 150.

Gum and sugar, coating of pills, 510.

H.

Hare's, Dr., hydrogen generator, 393.

Heating-box, for drying-closet, 301.
 the shop, arrangement for, 19.

Henry's apparatus for subliming calomel, 364.

Hermetically sealing glass tubes, 446.

Hessian crucibles, 78.

Holder, Gay-Lussac's, 326.

Hood, furnace, 124, 406.

Horizontal press, 215.

Hot air chamber, 110.
 filtering, 200.

Hydraulic press, Bramah's, 226, 229, 234.

Hydrochloric acid as a test, 545.

Hydrocyanic acid, distillation of, 341.

Hydrogen generator, Dr. Hare's, 393.
 reduction of metallic oxides by, 394.
 reduction of iron by, 395.

Hydrometer, Baume's, 63.
 Cartier's, 64.
 common, 63.
 Dica's, 67.
 Fahrenheit's, 62.
 for fixed oils, 69.
 milk, 70.
 Gay-Lussac's alcohol, 65.
 Nicholson's, 62.
 Sikes's, 66.
 syrup, 68.
 Twaddle's, 64.
 urine, 68.
 Zanetti's, 65.

Hydrometers or areometers, 61.

Hydrosulphate of ammonia as a test, 549.

Hydrosulphuric acid as a test, 546.

I.

Imperial measure, table of, 54.
 weights, table of, 50.
 weights and measures, standard of, 39.

Index, water, 110.

Incineration, 368.

Indicator for boilers, 110.

Infusion, process of, 245.
 and digestion, 118.
 pot, Squire's, 245, 472.
 mug, Alsop's, 245.

Infusions and decoctions, 470.

Inhalation of chloroform, 538.
 ether, 536.
 fumes, 540.
 gases, 532.
 vapours, 534.

Inhalers, chloroform, 539.
 ether, 536.
 for opium fumes, 540.

Injections, 514.

Intermediate crystallization, 377.
 pulverization, 162.

Iodide of potassium as a test, 552.

Iron, granulation of, 172.
 hydrated sesquioxide of, as an anti-dote, 379.
 ring for cutting glass, 435.

Isinglass plaster, transparent, 531.

J.

Joining or cementing glass tubes, 445.

Joint, water, 126.

K.

- Knife cradle, 145.
 cutting or slicing, 141.
 Mohr's self-supplying, 144.
 rolling, 145.
 root-cutting, 34, 35.
 plaster, 526.
 Knot, beer, 432.
 binding, 430.
 capping, 429.
 champagne, 433, 434.
 pyrotechnical, 431.
 tying of, 429.
 Kolle's condenser, 114.

L.

- Label-drawers, 31.
 Labels, arrangement of, 31.
 Laboratory, 34.
 alarum, 123.
 steam apparatus for, 135.
 Lamp, Berzelius's, 98.
 chimney, 98.
 gas, Faraday's, 24.
 glass spirit, 99.
 furnace, Cooper's, 99.
 Mitchell's, 97.
 spirit, with double draught, 440.
 Lead plaster, Shoemaker's apparatus for, 420.
 process of making, 419.
 Lever for removal of fixed stoppers, 425.
 Levigated chalk, conical mould for, 157, 173.
 Levigating apparatus, spring for, 157.
 vessel, 155.
 Levigation, spring pestle for, 156.
 Liebig's condenser, 323.
 Lighting the shop, arrangements for, 22.
 Lime water as a reagent, 555.
 Linctus, preparation of, 494.
 Liniments, 514.
 Liquefaction, 119.
 Litmus paper, 381.
 Lixiviation, 268.
 Loft or drying-room, 36.
 Lotions, 514.
 Lovi's beads, 65.
 Lozenges, preparation of, 495.
 Lunar caustic, 460.

M.

- Maceration, 245.
 Machine, blowing, 89, 306.
 Magnesia, calcination of, 369.
 furnace for calcining, 369.
 Marble mortar for trituration, 153.
 Means for preserving cleanliness, 465.
 Measure, apothecaries' or wine, 54.
 English apothecaries', 55.
 French decimal, 55.
 Imperial, 54.
 Measures of capacity, 54.
 Measuring and weighing, 38.
 Mechanical stirrer, 120, 138.
 Medicated honeys, 285.
 syrups, 282.
 vinegars, 279.
 wines, 279.
 Medicines, dispensing of, 463.
 Mellites, 284.
 Membrane capsules, 513.

- Metals, granulation of, 170.
 Menstrua, pharmaceutical, 236.
 Method of charging a retort, 318.
 holding the balance, 48.
 holding measure-glass, 49.
 of using test-papers, 382.
 Methods of obtaining solutions, 235.
 Mill, pugging, 307.
 Minim-meter, Alsop's, 46.
 Mitchell's lamp, 97.
 retort-stand, 100.
 separator, 186.
 Mitscherlich's condenser, 115.
 Miscellaneous operations, chiefly of a mechanical nature, 423.
 Mixed gas furnaces, 20, 97.
 Mixtures, preparation of, 484.
 Modes of solution, 237.
 Mohr's apparatus for benzoic acid, 362.
 for digesting with ether, 246.
 drying-closet, 302.
 press for extractions, 251.
 Real's press, 253.
 self-supplying cutting knife, 144.
 Mortar, cover for, 149.
 and spring pestle, 37, 147.
 for trituration, 153.
 Mother-water, 375.
 Mould, capsule, 510.
 for casting potash and lunar caustic, 460.
 zinc cylinder, 460.
 Moxas, preparation of, 516.

N.

- Neutralization, 381.
 Nicholson's hydrometer, 62.
 Nitrate of baryta as a test, 556.
 cobalt as a test, 557.
 potash as a test, 552.
 silver as a test, 558.
 ammonio, 558.
 Nitric acid, 546.
 Nitro-hydrochloric acid, 546.
 Noxious gases, escape for, 405.

O.

- Oil separators, 351-356.
 of bitter almonds, 353.
 black mustard, 353.
 cod liver, 409.
 of vitriol, 336.
 force of cohesion and adhesion in, 332.
 Oils, fixed, decoloration of the, 411.
 preparation of the, 409.
 essential, distillation of, 388.
 rectification of, 356.
 solution of, 339.
 Ointment, iodine, 414.
 mercurial, 414.
 Ointments, 414, 514.
 by chemical reaction, 417.
 medicated, 414.
 by mixing, 414.
 by solution, 116.
 Operating chamber or closet, closed, 461.
 Operations, furnace, 75.
 of glowing or heating to redness, 75.
 Oxalic acid as a test, 548.
 Oxalate of ammonia as a test, 550.
 Oxidation, 371.
 by chromic acid, 371.

Oxidation by combination, 371.
by nitric acid, 371.
Oxide of iron, its separation from salts before crystallization, 376.
Oxygenation, 371.

P.

Pans, evaporating, 109.
Paper filters, 194.
litmus, 381.
red cabbage, 382.
turmeric, 381.
Papin's digester, 368.
Pastils for cutting glass, 437.
Perforated false bottom, 108.
Pepys's blowpipe, 101.
Perchloride of gold as a test, 559.
iron as a test, 557.
mercury as a test, 558.
Pestle, spring, for levigation, 156.
and mortar, 37, 147.
Pharmaceutical menstrua, 236.
still, 345.
stove, 21, 125.
section of, 128.
Pharmacy, extemporaneous, 463, 497.
Phosphate of ammonia and soda, 551.
of soda, as a test, 555.
Pill-finisher, 507.
machine, 32.
mercurial, 504.
analysis of, 505.
Pills, coating of, with gelatin, 509.
gum and sugar, 510.
gilding and silvering, 508.
preparation of, 497.
excipients for, 497.
powders for enveloping, 507.
Pipette for bromine, 186.
Pipettes, 184, 185, 186.
Plain filter, 195.
Plaited filter, 197, 198.
Plaster, burnt, 422.
knife, 526.
lead, preparation of, 419.
spatulas, 519.
transparent isinglass, 531.
Plasters, preparation of spread, 516.
and soaps, 418.
apparatus for spreading, 524, 527, 528.
Plated still, 338.
Plunging syphon, 185.
Porphyzation, 154.
Porphyry slab and muller, 155.
Portable drying-closet, 305.
Portable furnace and appendages, 344.
common, 92, 94.
Pot, infusion, 245, 471.
Potash as a reagent, 551.
Potash, casting of, 460.
Poultices, 515.
Powdered drugs, table of, 168.
Powder-folder, 33.
Powdering-room, 36.
Powders, preparation of, 492.
Precipitation, 377.
Precipitates, washing, 191, 206.
Precipitating vessels, 378.
Preparation of aqueous solutions for extracts, 248.
beef's marrow, 412.
capsules, 511.
draughts, 486.
drops, 488, 496.

Preparation of electuaries, conserves, &c., 494.
emulsions, 488.
etheral and alcoholic solutions, for extracts, 262.
extract of valerian, 308.
of extracts in vacuo, 248, 262, 294.
glycerin, 421.
heavy carbonate of magnesia, 379.
hydrated sesquioxide of iron, 379.
lard, 411.
lozenges, 495.
lead plaster, 418.
mixtures, 484.
moxas, 516.
oleo-resinous extracts, 309.
pills, 497.
pine-apple syrup, 283.
powders, 492.
preserved juices, 278.
and purification of fixed oils and fats, 408.
of resins, 212, 309.
resinous tinctures, 270.
simple syrup, 280.
soaps, 418.
strawberry syrup, 283.
spread plasters, 516.
tinctures by maceration as directed in London Pharmacopœia, 266.
tinctures by Dr. Burton's method, 267.
by displacement, 268.
of waxed paper, 458.
Preserved juices or alcoolatures, 278.
Preservation of cerates and ointments, 483.
and rectification of essential oils, 356.
of syrups, 284.
Press, the, 213.
bags, 233.
Bramah's hydraulic, 226-236.
Count Real's filter, 252.
Beindorf's decoction, 473.
Mohr's, for extractions, 251.
horizontal or double screw, 215.
lever, 226.
Mohr's modification of Real's, 253.
screw, 213.
vertical or single screw, 224.
wedge, 231.
wooden screw, 221.
Presses, tincture, 232.
Pressing-box, 222, 226.
Process of alkalimetry and acidimetry, 382.
of clarification, 208.
crystallization, 373.
displacement, 247, 252, 268.
distillation, 316.
in glass vessels, 329.
decoloration, 210.
filtration, 187.
evaporation, 286.
expression, 232.
precipitation, 377.
of solution, 235.
Protochloride of tin as a test, 588.
Pugging mill, 307.
Purification of salts from oxide of iron, 376.
Pulverization of drugs, 146.
apparatus for, 151.
by mediation, 162.
Pyrotechnical knot, 431.

Q.

Quilled receivers, 316.

R.

- Rationale of the action of direct heat on organic matter, 290.
 Reading the prescription, 475.
 Reagents, list of, 542.
 Real's, Count, press, 252.
 Receiver, Florentine, 351.
 quilled, 316.
 tubulated, 315.
 Rectification of essential oils, 356.
 of ether, 357.
 Red cabbage, infusion of, 381.
 Reduction, process of, 369.
 of iron by hydrogen, 395.
 metallic oxides by hydrogen, 394.
 apparatus for, 394.
 Redwood's apparatus for preparing extracts in vacuo, 294.
 gas blowpipe, 100.
 pharmaceutical stove, 125.
 section of, 128.
 Removal of fixed stoppers, 424.
 Retort, badly formed, 314, 315.
 capped, 322.
 funnel, 318.
 method of charging plain, 318.
 with receiver and adapter, 321.
 in sand-pot, 319, 344.
 stand, 326.
 Mitchell's, 100.
 well-formed, 313, 314.
 Reverberatory furnace, 91.
 Rhubarb, torrefaction of, 366.
 Rickets's gas stove or furnace, 20.
 Ring for cutting glass, 435.
 Roasting, process of, 369.
 Rolling knife, 145.
 Room, drying, 36.
 powdering, 36.
 store, 35.
 Root-cutting knife, 34, 35.
 Rouser, the, 354.

S.

- Saccharine solutions, 280.
 Saccharometer-cup, 281.
 Saccharometers, 68.
 Safety-tubes, 341, 400.
 Sand-bath, 112, 325.
 Saponification, 119, 418.
 Screw press, 213.
 Sealing glass tubes, 443.
 Section of pharmaceutical stove, 128.
 Seftstroem's furnaces, 86.
 Selection of glass tubes, 439.
 Separating funnel, 186.
 Separator, Mitchell's, 186.
 Separators, 186.
 oil, 355.
 Shoemaker and Smull's steam generator, 132.
 Shoemaker's apparatus for making lead plaster, 420.
 Shop, arrangement of, 18.
 for heating, 19.
 for lighting, 22.
 ventilating, 24.
 or dispensary, 17.
 division of, into compartments, 27.
 Sifting apparatus, 160.
 Sikes's hydrometer, 66.
 Silver, granulation of, 172.
 solution of, 389.
 Silvering and gilding of pills, 508.

- Simple syrup, preparation of, 280.
 Single screw or vertical press, 224.
 Slicing knife, 141.
 Slides, counter, 31.
 Small plated still, 338.
 Smith's displacement apparatus, 260.
 Smoking of opium, 540.
 Soap, amygdaline or medicinal, 418.
 Soaps and plasters, 418.
 Soaps, medicinal, 419.
 preparation of, 418.
 Solid gas flame, 440.
 Solution, 119, 235.
 of essential oils, 339.
 of silver, 339.
 of starch, 559.
 Solutions, oily, 279.
 saccharine, 280.
 Sources and management of heat, 75.
 Spatulas, plaster, 519.
 Specific gravities, apparatus for taking, 57, 71.
 determination of, 55.
 Specific gravity beads, 65.
 bottle, 60.
 bucket, 59.
 syphon, 73.
 Spirit hydrometer, Baumé's, 64.
 lamp, with double draught, 440.
 Berzelius's, 98.
 Mitchell's, 97.
 Spirits, distillation of, 118.
 Spontaneous evaporation, 298.
 apparatus for, 303.
 Sponge, bleaching of, 397.
 Spongio-pilne, 516.
 Spring pestle, 147.
 for levigation, 156.
 and mortar, 37, 147.
 for levigating apparatus, 158.
 Standard of French decimal weights, 40.
 Imperial weights and measures, 39.
 Steam apparatus, 107.
 for laboratory, 135.
 bath, 291.
 boiler, 129, 130, 132.
 funnel, 109, 358.
 jets, ventilation, 139.
 jets, 139.
 Steelyard, 42.
 Still and condenser, 349.
 head, 109.
 plated, 338.
 stoneware, 316.
 Stirrer, 120, 138.
 Stirring extracts, apparatus for, 121.
 Stoneware condenser, 347.
 still, 346.
 Stoppering of glass bottles, 423.
 Stoppers, removal of fixed, 424.
 lever for removing fixed, 425.
 Store cellar, 36.
 room, 35.
 Stove, anthracite, for store, 22.
 gas, 19, 20.
 Redwood's pharmaceutical, 125.
 section of, 128.
 String-boxes, 33.
 Sublimation, 362.
 of benzoic acid, 361.
 apparatus for the, 361.
 of calomel, 362.
 apparatus for the, 368.
 of corrosive sublimate, 364.
 Henry's apparatus for, of calomel, 364.
 of metallic arsenic, 366.

Sublimed benzoic acid, 362.
 Sugar and gum, coating of pills with, 510.
 Sulphate of ammonia as a test, 557.
 of copper, as a test, 557.
 of indigo, as a test, 559.
 of lime, as a test, 555.
 Sulphuret of ammonium, preparation of, 392.
 Sulphuretted hydrogen, generation and absorption of, 391.
 Sulphuric acid as a test, 532.
 Suppositories, 515.
 Surface evaporation, 120.
 Syphon, Negretti's, 182.
 platina, refrigerating, 182.
 plunging, 185.
 specific gravity, 73.
 syringe, 182.
 theory of its action, 177.
 Syphons, 177, 178, 180, 181, 182, 183.
 Syringe blowpipe, 101.
 glass, 48.
 pipette, 186.
 Syrups, 280.
 medicated, 282.
 straining of, 281.
 preservation of, 284.
 of vegetable juices, 283.
 Syrup, pine-apple, 283.
 simple, 280.
 strawberry, 283.

T.

Table for acetic acid, 564.
 alcohol, 567.
 ammonia, 566.
 apothecaries' weight, 51.
 measure, 54.
 avoirdupois or imperial weight, 50.
 of equivalents of troy and avoirdupois weights, 51.
 of fusing-points, 106.
 French decimal measures, 55.
 weights, 54.
 Imperial apothecaries' measure, 55.
 measure, 54.
 for muriatic acid, 563.
 nitric acid, 562.
 for solutions of potash, 565.
 of powdered drugs, 168.
 of solutions of soda, 566.
 of solubilities, 239.
 for sulphuric acid, 561.
 of troy weights, 50.
 Tables, specific gravity, 73, 74.
 Tartaric acid as a test, 549.
 Taylor's filter, 192.
 Test-papers, 381.
 tubes, 541.
 Testing, apparatus for, 541.
 Theory of decantation, 174.
 of hydraulic press, 227.
 of action of the syphon, 178.
 Thermometer, centigrade, 103.
 Fahrenheit's, 103.
 Thermometers, 102-105.
 mode of reducing the degrees of, 103.
 Thermometrical tables, 104, 105.
 Tin, granulation of, 171.
 Tincture presses, 232.
 Tinctures, ethereal, apparatus for making, 264.
 preparation of, by maceration, 266.
 by displacement, 268.

Torrefaction, process of, 366.
 of rhubarb, 366.
 Transparent isinglass plaster, 531.
 Trituration, mortar for, 153.
 Trough, chopping, 140.
 cutting, Chinese, 145.
 Tub, cooling or condensing, 113.
 Beindorf's, 113.
 Tubulated receiver, 315.
 retort, 314.
 Tube connexions, 453, 455.
 Tubes, bent, 441.
 Turmeric paper, 381.
 Twaddle's hydrometers, 64.
 Tying of knots, 429.

U.

Urinometer, 68.

V.

Vacuum apparatus, 297.
 filter, 193.
 Valve, ventilating, Dr. Arnott's, 25.
 Vaporization, 119.
 Vapours, inhalation of, 534.
 Vegetable juices, syrups of, 283.
 Ventilating the shop, 24.
 valve, Dr. Arnott's, 25.
 Ventilation, arrangements for, 24.
 steam jet, 139.
 Vertical press, 224.
 Vessel, levigating, 155.
 Vessels for crystallization, 377.
 precipitation, 378.
 Vinegars, medicated, 279.
 Vitriol, oil of, distillation of, 336.
 forces of cohesion and adhesion in, 332.

W.

Wash-bottles, 207, 208.
 Washing precipitates, 191, 206.
 Water blowpipe, 442.
 mode of using the, 443.
 bath, 291.
 funnel, 200.
 forces of cohesion and adhesion in, 333.
 index, 110.
 joint, 126.
 Waxed paper, preparation of, 458.
 Weighing and measuring, 88.
 Weight, apothecaries', table of, 51.
 avoirdupois, table of, 50.
 French decimal weight, 54.
 standard of, 40.
 imperial, standard of, 39.
 table of, 50.
 troy, 50.
 Welter's safety-tube, 401.
 Wind-furnace, 80.
 Wines, medicated, 279.
 Wohler's apparatus for anhydrous hydrocyanic acid, 342.
 Wollaston's blowpipe, 101.
 Worm-tub, common, 113.
 Woulf's apparatus, 401, 404.

Z.

Zanetti's hydrometers, 65.
 Zinc cylinders, mould for casting, 322.
 granulation of, 170.

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